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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 1, January 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● National Center for Radiological Health

Reports

Gross Radioactivity of the Solids in Selected Surface Waters of the United States, 1961-1965

Elmo C. Julian [1]

Gross radioactivity has been expressed in pCi/liter of water but to understand the movement of radiological contamination in the absence of flow data, the consideration of radioactivity in the suspended and dissolved solids in pCi/g is quite useful. The gross radioactivity of the solids in some surface waters of the United States is presented and interpreted in this report with the data from stations of the Water Pollution Surveillance System for the years 1961 through 1965.

Radioactivity levels in surface waters as modified by seasonal runoff patterns are reported. The radioactivity of solids collected below two production reactor facilities was measured and a trend is indicated.

The history of the monitoring of gross radioactivity in surface waters of the United States and the analytical methods employed have been described in reports by the former Division of Water Supply and Pollution Control of the U.S. Public Health Service, now the Federal Water Pollution Control Administration, U.S. Department of the Interior (*1*). Water quality is customarily expressed in the form of weight per unit volume (mg/liter). A water sample as obtained from a stream will contain solid material in suspension and this suspended material is considered a part of the water of the stream for defining the water quality. Gross beta radioactivity associated with the suspended solids is not highly significant for domestic water use since nearly all suspended matter is removed in most instances by municipal water treatment processes (*2*). The presence of large quantities of suspended solids leads to proportionately large values for the gross radioactivity, since gross radioactivity levels in water are expressed only in picocuries per liter (pCi/liter). These complications have been recognized and discussed (*2,3*). This effect is illustrated below for a sample collected October 18, 1966, from Laredo, Tex., on the Rio Grande.

	Solids (mg/liter)	Water quality (pCi/liter)		Solids quality (pCi/g)	
		Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity
Dissolved solids	536	4 ± 2	26 ± 2	7 ± 4	49 ± 4
Suspended solids	5,590	125 ± 41	305 ± 43	22 ± 7	55 ± 7

If a nuclear facility adds highly radioactive materials to a stream, the resulting weight of solid radioactive material is negligible when compared to the weight of solids already present in the stream; consequently, the radioactivity in picocuries per gram will increase. To recognize significant changes of radioactivity in water, the calculation of results as picocuries per gram is required. The reporting of gross radioactivity in the surface waters of the United States has included no discussion of gross radioactivity on the weight basis (*4*).

In this report, the gross radioactivity in pCi/liter is considered as water quality and in pCi/gram as solids quality.

[1] Mr. Julian is in charge of the Radiochemistry Unit of the Water Quality Activities, Division of Pollution Surveillance, Federal Water Pollution Control Administration, U.S. Department of the Interior, 1014 Broadway, Cincinnati, Ohio 45202.

The following radiological characteristics of the solids are considered:

1. Natural radioactivity—The natural radioactivity results from naturally occurring radionuclides such as potassium–40, thorium–232, uranium–238, and other decay products from uranium and thorium.
2. Fallout—This radioactive material consists of insoluble and soluble fission products and neutron-activated materials from nuclear weapons tests.
3. Reactor material—Production reactors in their operation yield, in addition to fission products, neutron-activated materials which must be disposed of as waste material. After appropriate decay periods and dilutions, these wastes may be safely discharged to the stream.
4. Uranium and thorium mining and milling wastes—these operations may release a variety of decay products, such as radium.

This study is divided into two parts. In the first part, twelve stations of the Water Pollution Surveillance System (WPSS) on eleven rivers were selected to show water quality and solids quality near the mouth of each river and at a few upstream locations. Solids quality data were calculated from existing water quality data for the period July 1, 1961 through September 30, 1965. Tables 1 through 5 summarize these data. The data in all the tables and figures are reported at the 2 σ counting error level. The Pasco, Wash., and Port Wentworth, Ga., stations are downstream from production reactor complexes. Data from these stations are given, but are omitted from the general averages and are treated separately. To show a geographical perspective, the station locations are shown in figure 1.

Figure 1. Selected stations of the Water Pollution Surveillance System for a study of gross radioactivity of the solids in the waters of the United States, 1961–1965

Table 1. Alpha radioactivity in suspended solids

Station	1961				1962								1963								1964								1965					
	July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	1	13	0	0	0	4	0	5	0	11	0	0	0	0	0	8	0	0	1	25	0	0	0	7	0	0
Hudson River: Poughkeepsie, N. Y.	0	0	0	4	0	0	0	4	1	19	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	3	0	0	0	0
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	0	0	8	1	6	0	6	0	0	1	14	4	22	0	0	0	0
Savannah River: Port Wentworth, Ga.	1	9	0	10	0	7	0	0	0	10	0	0	1	17	0	0	0	6	0	0	0	7	1	9	0	3	0	8	0	9	0	4	0	9
Lake Superior: Duluth, Minn.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mississippi River: St. Paul, Minn.	1	7	0	0	0	9	0	4	1	6	0	0	0	9	0	8	0	5	0	0	0	0	0	0	0	11	0	11	0	0	0	7	0	7
New Orleans, La.	1	12	7	15	5	20	3	15	0	9	0	5	3	16	1	8	0	0	0	0	3	18	5	18	1	7	1	11	5	18	16	42	4	19
Missouri River: Williston, N. Dak.	4	12	5	15	4	10	79	14	0	0	2	6	2	13	2	15	1	13	1	4	1	7	2	13	1	14	2	8	2	6	2	15	1	16
St. Joseph, Mo.	17	19	2	5	3	8	25	24	3	10	4	7	15	11	33	16	7	19	2	18	1	3	23	16	16	19	3	10	13	14	21	15	18	19
Ohio River: Cairo, Ill.	3	29	2	11	3	14	5	15	0	0	4	48	15	74	5	54	1	11	1	18	7	45	4	24	0	7	3	20	6	24	2	12	0	11
Rio Grande: Laredo, Tex.	20	19	2	9	1	4	2	4	35	10	6	4	1	3	17	8	29	16	13	17	1	4	74	13	27	10	4	9	0	6	11	9	9	9
Colorado River: Parker Dam, Aris.	1	6	0	0	1	2	1	2	0	2	1	6	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia River: Wenatchee, Wash.	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasco, Wash.	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	10	0	0	0	0	0	5	0	0	0	0	0	3	0	2	0	0
Average [a]	6	10	2	6	1	7	12	8	4	6	2	9	3	12	5	11	3	6	1	5	1	7	9	8	4	6	1	10	3	8	4	9	3	7

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 2. Alpha radioactivity in dissolved solids

Station	1961				1962								1963								1964								1965					
	July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson River: Poughkeepsie, N. Y.	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	2	0	1	0	1	0	0	1	2	1	2	0	0	0	0	0	0
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	1	0	2	0	1	0	1	0	1	1	3	0	0	0	3	0	3
Savannah River: Port Wentworth, Ga.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0
Lake Superior: Duluth, Minn.	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mississippi River: St. Paul, Minn.	2	6	1	3	1	4	2	6	2	6	0	1	1	4	2	6	2	6	2	7	1	2	2	5	2	6	2	5	2	7	2	8	1	4
New Orleans, La.	0	0	1	4	1	4	1	6	1	4	2	7	0	1	0	1	2	6	1	4	1	2	1	5	1	4	1	5	1	3	1	5	1	4
Missouri River: Williston, N. Dak.	3	6	5	10	2	6	4	9	2	5	3	5	5	10	5	9	3	6	5	9	5	11	4	7	3	7	6	11	6	12	3	8	4	16
St. Joseph, Mo.	4	8	5	10	3	7	2	5	3	6	6	12	4	9	5	30	4	10	4	7	4	9	3	7	5	9	5	10	3	9	4	9	4	8
Ohio River: Cairo, Ill.	1	4	0	0	1	4	0	1	0	1	1	3	1	3	0	0	0	1	0	1	1	4	0	0	1	3	1	4	0	0	0	1	0	0
Rio Grande: Laredo, Tex.	4	6	4	7	2	2	2	3	4	7	6	10	4	4	2	2	5	7	5	8	4	6	2	4	2	3	3	6	4	7	3	5	3	6
Colorado River: Parker Dam, Ariz.	7	9	7	9	7	9	7	8	8	10	7	9	9	11	7	10	7	9	10	15	7	9	11	14	7	8	7	12	9	11	7	9	8	10
Columbia River: Wenatchee, Wash.	1	2	1	11	1	5	1	11	0	0	1	7	1	11	1	4	1	5	0	4	1	8	0	3	0	0	1	6	1	10	1	5	0	3
Pasco, Wash.	0	1	0	3	1	9	1	2	0	0	1	5	1	6	1	5	0	0	0	4	1	7	0	5	0	3	1	7	1	6	1	6	1	5
Average [a]	2	4	2	5	2	4	2	5	2	4	2	5	2	5	2	6	2	4	2	5	2	4	2	4	2	4	2	5	2	5	2	4	2	5

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 3. Beta radioactivity in suspended solids

Station	1961				1962								1963								1964								1965					
	July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	9	340	8	221	16	354	11	211	12	302	9	358	5	147	2	55	3	91	3	70	7	223	2	49	2	83
Hudson River: Poughkeepsie, N. Y.	3	52	6	94	17	482	6	104	4	136	8	192	11	275	8	183	2	92	2	83	5	145	3	84	6	129	3	70	4	73	2	57	1	31
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	6	122	4	116	8	124	4	75	2	50	1	30	14	86	0	10	1	23
Savannah River: Port Wentworth, Ga.	6	104	5	120	25	519	13	312	7	156	7	171	26	490	23	364	14	328	4	207	7	205	14	202	7	171	4	92	4	89	3	86	3	106
Lake Superior: Duluth, Minn.	1	43	2	79	6	252	5	110	4	137	2	81	5	123	2	31	2	42	2	63	1	21	3	103	1	35	0	0	3	65	1	24	1	44
Mississippi River: St. Paul, Minn.	2	7	14	446	5	137	25	247	14	211	7	164	6	154	28	342	8	188	4	114	2	75	10	166	3	90	3	106	1	36	4	93	2	53
New Orleans, La.	2	17	29	146	50	233	55	195	13	116	15	201	31	197	37	232	4	5	1	25	16	123	31	98	8	67	6	58	23	94	30	85	14	66
Missouri River: Williston, N. Dak.	21	44	16	97	14	94	362	231	100	126	109	101	26	169	26	210	12	178	10	110	6	95	18	139	5	68	5	32	13	60	8	74	5	63
St. Joseph, Mo.	41	42	91	269	92	151	251	164	131	152	23	84	89	99	299	159	48	130	11	76	7	44	154	162	55	61	14	69	37	60	90	64	51	57
Ohio River: Cairo, Ill.	6	69	24	126	81	400	30	199	3	104	10	88	125	408	41	421	2	46	1	35	37	202	23	159	3	59	5	49	20	87	7	84	1	35
Rio Grande: Laredo, Tex.	42	31	35	74	9	54	48	141	362	122	112	278	22	100	319	218	705	155	101	122	32	88	456	113	165	70	19	53	7	110	48	54	30	57
Colorado River: Parker Dam, Ariz.	5	46	4	32	13	98	2	15	13	111	4	35	27	233	1	48	1	44	1	44	2	99	1	26	2	49	1	13	1	19	1	44	1	18
Columbia River: Wenatchee, Wash.	1	18	3	83	5	139	4	89	3	78	2	52	3	76	6	126	7	88	1	67	1	24	2	56	2	61	3	68	2	54	0	11	1	32
Pasco, Wash.	23	738	82	2176	65	2239	60	1674	38	1143	47	1556	48	1279	75	2014	42	1475	90	3716	69	2137	236	7281	62	1834	64	1694	51	1907	47	1313	44	2044
Average [a]	12	37	22	145	30	204	79	150	60	149	27	136	33	199	71	198	67	121	12	104	10	99	59	103	21	69	5	52	11	81	16	54	9	47

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 4. Beta radioactivity in dissolved solids

Station	1961				1962								1963								1964								1965					
	July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	11	83	17	225	33	333	14	185	21	155	13	147	13	139	9	87	10	57	10	84	7	66	5	66	6	53
Hudson River: Poughkeepsie, N. Y.	3	22	11	74	36	231	14	116	14	75	57	420	21	111	25	184	24	129	22	107	15	69	11	79	18	58	23	41	10	58	8	58	9	36
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	28	120	13	55	9	51	10	53	10	33	8	33	5	37	5	27	7	31
Savannah River: Port Wentworth, Ga.	10	157	34	440	38	608	27	399	45	702	24	417	39	461	38	456	25	258	15	172	20	284	16	205	17	158	11	141	7	140	8	129	8	117
Lake Superior: Duluth, Minn.	2	21	3	43	4	42	6	60	5	51	8	106	6	71	10	68	10	97	6	63	5	56	7	107	5	31	5	60	6	70	3	39	4	43
Mississippi River: St. Paul, Minn.	7	25	39	145	14	53	58	236	36	111	23	81	25	90	76	246	54	158	26	80	19	65	43	138	31	102	23	86	18	.0	26	91	21	68
New Orleans, La.	12	46	23	97	26	134	29	125	20	67	26	96	23	97	34	132	30	95	27	77	16	61	17	78	20	62	15	56	11	52	11	53	13	45
Missouri River: Williston, N. Dak.	12	22	19	49	19	44	27	63	25	63	26	46	39	82	47	108	45	93	28	53	19	40	29	63	18	40	18	36	28	48	17	40	16	37
St. Joseph, Mo.	14	27	74	160	37	103	54	144	52	103	29	56	35	81	50	85	32	110	21	40	20	40	84	193	32	60	28	52	23	62	21	52	21	43
Ohio River: Cairo, Ill.	9	40	17	102	30	158	20	91	19	107	19	81	24	124	36	155	21	117	18	90	12	62	18	69	13	51	11	44	7	29	8	40	8	35
Rio Grande: Laredo, Tex.	6	11	29	35	19	27	34	60	28	54	33	37	40	47	61	103	46	73	22	35	19	28	31	59	26	47	14	24	21	51	13	26	16	26
Colorado River: Parker Dam, Ariz.	12	15	27	36	41	50	22	24	23	27	31	41	78	90	26	36	21	27	17	24	18	25	23	31	18	20	17	32	20	25	21	25	23	25
Columbia River: Wenatchee, Wash.	3	24	6	59	9	71	7	55	7	60	9	87	17	151	16	87	13	96	14	136	12	96	8	66	11	74	9	84	6	64	6	57	6	52
Pasco, Wash.	234	1965	738	6695	568	4764	144	1215	282	2304	381	4082	494	4350	374	2810	465	3284	843	7167	655	5678	696	5028	459	3825	667	5910	324	2940	213	1739	251	2203
Average *	8	25	25	80	24	91	27	97	22	73	25	116	32	116	36	124	29	106	19	76	15	61	24	85	18	53	15	53	14	53	12	48	13	41

* Except for Port Wentworth, Ga., and Pasco, Wash.

Table 5. Suspended and dissolved solids

Station	1961				1962								1963								1964								1965					
	July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept		Oct–Dec		Jan–Mar		Apr–June		July–Sept	
	mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter	
	S[a]	D[a]	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	29	185	36	87	35	99	51	82	38	138	24	90	33	92	41	112	35	172	45	120	32	99	40	81	22	124
Hudson River: Poughkeepsie, N. Y.	45	146	58	153	36	159	47	126	34	188	44	140	43	150	40	140	28	182	29	210	38	239	36	145	47	329	44	612	62	176	37	143	25	257
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	38	244	31	241	61	160	47	180	46	307	44	243	149	143	33	171	32	245
Savannah River: Port Wentworth, Ga.	50	70	45	128	50	77	42	74	44	81	39	61	58	96	54	82	40	108	32	220	39	68	70	79	39	118	48	77	33	67	33	61	30	79
Lake Superior: Duluth, Minn.	33	109	35	81	30	88	45	102	34	100	26	70	39	86	45	148	36	100	27	90	33	83	31	102	39	139	32	77	31	80	28	76	26	104
Mississippi River: St. Paul, Minn.	39	312	32	270	35	292	104	304	69	344	41	289	37	275	58	312	45	341	36	321	36	293	60	308	31	321	31	264	28	264	46	283	37	304
New Orleans, La.	80	265	187	242	249	200	307	255	85	312	84	273	163	236	169	261	48	316	27	345	140	266	290	225	95	321	103	265	250	204	297	216	195	297
Missouri River: Williston, N. Dak.	453	514	221	466	147	450	3121	453	919	398	682	559	217	505	135	458	69	507	88	536	77	481	151	482	66	446	154	516	196	606	116	427	79	421
St. Joseph, Mo.	977	506	324	529	548	388	1329	373	987	508	285	521	667	473	1713	587	372	406	141	534	119	504	1866	450	794	540	225	532	749	401	1462	411	950	494
Ohio River: Cairo, Ill.	76	219	190	167	220	194	108	228	33	188	119	234	345	201	91	239	39	184	33	215	203	219	142	261	45	253	128	246	228	237	88	206	31	227
Rio Grande: Laredo, Tex.	993	608	250	619	177	698	295	611	3000	527	811	746	177	852	1263	662	6011	634	707	662	345	681	4049	603	1548	605	264	608	51	625	803	554	535	592
Colorado River: Parker Dam, Ariz.	109	848	132	749	123	818	149	874	119	840	137	766	115	813	79	740	36	781	31	698	26	725	39	736	42	990	44	548	34	775	32	810	33	888
Columbia River: Wenatchee, Wash.	41	133	34	108	36	119	41	135	38	114	38	100	44	114	35	185	58	135	22	103	40	126	35	118	40	186	40	105	29	99	31	115	23	110
Pasco, Wash.	33	127	37	111	31	120	46	139	33	124	36	99	38	116	38	135	31	141	27	128	32	116	36	131	35	161	39	114	35	111	32	115	25	118
Average [b]	285	366	146	338	160	341	555	346	486	323	209	344	171	346	334	347	568	331	100	337	96	322	566	310	236	384	96	345	153	309	251	291	166	339

[a] S—suspended; D—dissolved solids
[b] Except for Port Wentworth, Ga., and Pasco, Wash.

In the second part of the study, all stations of the Federal Water Pollution Control Administration's Water Pollution Surveillance System (WPSS) for which data were available were used for the manual computation of solids quality data. Computations were made for the following three 1-month periods:

1. June 1961—Essentially background levels of gross beta radioactivity were obtained. These low levels are attributed to the weapons testing moratorium then in effect.
2. December 1961—Higher levels of gross beta radioactivity had occurred, due to fallout from the resumption of weapons testing.
3. December 1965—A more recent period was selected to indicate current levels of gross beta radioactivity.

Table 6 presents the results of these computations for all WPPS stations. They are arranged in groups corresponding to the basin-oriented regions of the Federal Water Pollution Control Administration, U.S. Department of the Interior.

Results

Data from tables 1 through 5 are graphically shown as sets of five curves in figure 2. The selected stations for this study are listed in each of the tables.

Interpretation

Figure 2 shows the relative changes in the listed parameters over the stated time period. These parameters are discussed below:

Solids—In figure 2 (A), the average dissolved solids level based on ten to twelve stations is

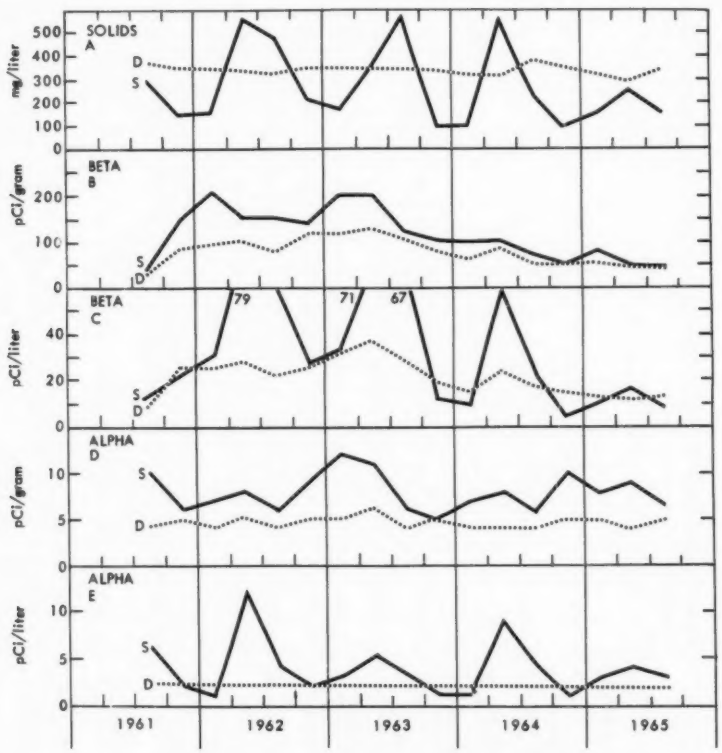

Figure 2. Average gross radioactivity at selected stations of the Water Pollution Surveillance System, 1961–1965

relatively constant over this time period. The suspended solids levels reflect seasonal runoff patterns.

Beta radioactivity—In figure 2 (C), the gross beta radioactivity on dissolved solids as water quality (pCi/liter) shows a drop of approximately 50 percent for calendar years 1964 and 1965 as compared with the period 1961 through 1963. The higher levels during the earlier period are probably a result of fallout transport via water runoff. The suspended solids show clearly the seasonal effects and pattern quite clearly. In figure 2 (B), the beta radioactivity as solids quality on dissolved solids roughly follow the trend of figure 2 (C).

The gross beta radioactivity levels downstream from production reactors are characterized by the discharges of radioactive waste material. Figure 3 shows the gross beta radioactivity on dissolved solids for Pasco, Wash., on the Columbia River. Figure 4 shows the gross beta radioactivity on dissolved solids for Port Wentworth, Ga., on the Savannah River. In these two figures, monthly averages were used in order to show the variability of the levels.

Figure 3 represents the gross beta radioactivity in both water quality and solids quality. The water quality data show less variation than the solids quality data. The discharge of radionuclides superimposed upon the relatively low levels of dissolved solids produces a dramatic increase in the radiological quality of these solids. Figure 3 also shows the average results of solid quality for Wenatchee, Wash. The results reflect the natural level of beta radioactivity upstream from the reactor complex. It is not practical to plot the water quality data on this same scale.

The gross beta radioactivity on dissolved solids for Port Wentworth, Ga., in both water quality and solids quality are shown in figure 4. Again, there are no significant differences in water quality, while the changes in solids quality are dramatic. A reduction in the levels of radioactivity can be noted during and after September 1963.

Alpha radioactivity—In figure 2 (E), the gross alpha radioactivity in the dissolved solids as water quality (pCi/liter) shows a constant level of 2 pCi/liter for the entire period. For the suspended solids, the same parameter shows the effects of the seasonal runoff pattern.

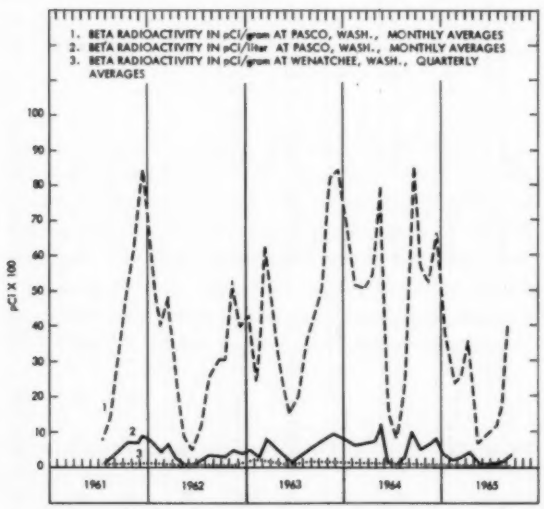

Figure 3. Gross beta radioactivity on dissolved solids in the Columbia River, 1961–1965

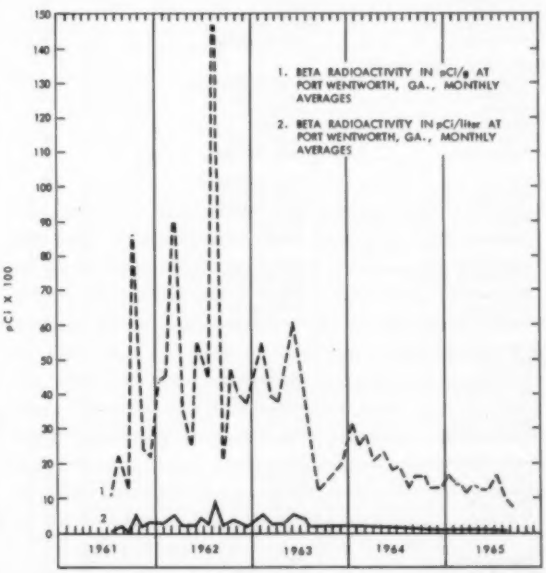

Figure 4. Gross beta radioactivity on dissolved solids in the Savannah River at Port Wentworth, Ga., 1961–1965

Table 6. Gross radioactivity in surface waters

Station and region	River	June 1961				December 1961				December 1965			
		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)	
		D[a]	S[a]	D	S	D	S	D	S	D	S	D	S
NORTHEAST REGION													
Enfield Dam	Connecticut									0	0	65	0
Northfield	Connecticut	0	0	0	0	0	0	188	265				
Philadelphia	Delaware	0	0	0	0	0	12	413	1,750	0	26	33	51
Martins Creek	Delaware	0	0	0	0	0	0	296	433				
Poughkeepsie	Hudson	0	0	3	39	0	13	118	128	0	0	51	48
Lowell	Merrimack	0	0	0	0	0	0	284	567				
Philadelphia	Schuylkill	0	0	0	0	4	8	122	181				
MIDDLE ATLANTIC REGION													
Washington, D. C.	Potomac									3	0	5	0
Great Falls	Potomac	0	0	0	0			152	424				
Williamsport	Potomac	0	0	0	0	0	0	120	339				
Conowingo	Susquehanna	6	0	18	0	0	0	129	316	0	0	15	0
Sayre	Susquehanna	0	0	0	0	0	0	165	306				
SOUTHEAST REGION													
Chattahoochee	Apalachicola	0	0	0	0	0	0	43	27				
Columbus	Chattahoochee	0	0	0	0	0	0	208	288				
Atlanta	Chattahoochee	0	0	11	10			127	223				
Kingston	Clinch									2	7	116	284
Clinton	Clinch									0	0	33	0
Rome	Coosa									0	34	48	69
Century	Escambia	0	23	0	0	0	0	171	292				
North Augusta	Savannah	0	0	0	0	0	0	145	235				
Port Wentworth	Savannah			38	18	0	0	1,395	0	0	0	126	141
Pickwick Landing	Tennessee					0	5	319	270				
Bridgeport	Tennessee	0	0	463	0	0	0	468	280				
Chattanooga	Tennessee	0	13	339	0	0	20	578	548	0	0	35	83
Columbus	Tombigbee					0	13	406	893				
OHIO BASIN REGION													
Pittsburgh	Allegheny	2	0	0	0	0	0	30	16				
Cheatham Lock	Cumberland									0	0	58	0
Winfield Dam	Kanawha	0	0	0	0	0	0	89	147				
Cincinnati	Little Miami	< 1	6	2	0	0	6	176	555				
Cairo	Ohio	12	60	0	0	0	11	102	126	3	0	31	36
Evansville	Ohio	13	11	0	0	0	37	77	281				
Louisville	Ohio	0	0	0	0	0	0	296	433				
Cincinnati	Ohio	0	10	0	0	0	20	77	207				
Huntington	Ohio	0	0	0	0	0	0	83	244				
Toronto	Ohio									0	0	35	0
New Harmony	Wabash									5	0	37	40
Pittsburgh	Monongahela	0	0	0	0	2	17	79	157				
GREAT LAKES REGION													
Massena	Saint Lawrence	2	6	0	0	0	0	82	140				
Buffalo	Lake Erie	0	0	0	0	0	10	52	147				
Toledo	Maumee									4	21	55	85
Detroit	Detroit	0	0	0	0	0	0	96	192				
Port Huron	Saint Clair	0	0	0	0	0	0	26	69				
Milwaukee	Lake Michigan	2	8	0	0	5	0	48	108				
Gary	Lake Michigan	0	0	0	0	0	0	67	280				
Duluth	Lake Superior	0	0	0	0	0	0	42	92	0	0	49	0
Sault St. Marie	Lake Superior	0	0	0	0	10	0	70	99				
Peoria	Illinois	1	7	31	0	0	11	56	271	7	34	24	119
Grafton	Illinois					< 1	1	62	91	6	22	12	67
Cape Girardeau	Mississippi	3	16	0	0	7	0	78	195				
East Saint Louis	Mississippi	0	0	3	33	3	0	105	264	8	30	40	91
Burlington	Mississippi	4	10	0	0	0	18	58	109				
Dubuque	Mississippi	0	0	0	0	9	0	102	267				
Saint Paul	Mississippi	6	23	0	0	4	0	111	629	7	0	53	0
MISSOURI BASIN REGION													
Hardin	Big Horn									13	0	28	28
Sioux Falls	Big Sioux	5	5	0	8	< 1	1	71	151				
DeSoto	Kansas									7	0	30	56
Saint Louis	Missouri	11	30	8	28	5	7	103	189				
Kansas City	Missouri	8	15	0	18	3	6	59	125				
Saint Joseph	Missouri	0	3	0	30	10	0	55	78	13	24	51	79
Omaha	Missouri	8	8	24	14	4	10	55	24				
Yankton	Missouri	8	0	16	0	8	13	39	57				
Bismarck	Missouri	9	0	7	0			29	4	7	12	43	39
Williston	Missouri	11	26	15	38			39	43	10	0	33	63
Henry	North Platte					34	0	65	162	44	20	68	181
Plattsmouth	Platte					14	3	3	100	16	22	48	75
Grand Forks	North Red	3	0	0	0					4	0	56	0
Baudette	Rainy									0	0	147	79
Int'l. Falls	Rainy					0	0	210	157				
Julesburg	South Platte	24	7	31	0	27	15	49	54	26	27	43	107
Sidney	Yellowstone	4	4	8	77	10	14	42	41	7	24	25	24

Table 6. Gross radioactivity in surface waters—continued

Station and region	River	June 1961				December 1961				December 1965			
		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)	
		D	S	D	S	D	S	D	S	D	S	D	S
SOUTH CENTRAL REGION													
Pendleton Ferry	Arkansas	0	3	0	0	4	20	136	259				
Ponca City	Arkansas	4	16	11	0	0	0	69	231	5	23	7	50
Coolidge	Arkansas	15	0	1	28	13	9	28	44	9	13	20	74
Morgan City	Atchafalaya									4	18	28	56
New Orleans	Mississippi	3	12	13	17	4	32	154	189	3	0	27	0
New Roads	Mississippi									6	23	49	114
Delta	Mississippi	9	27	9	3	6	25	118	554				
West Memphis	Mississippi	4	8	4	22	4	27	130	327				
Alexandria	Red	8	8	0	0	8	18	108	183	1	22	29	65
Index	Red	0	7	0	0	6	16	111	442				
Denison	Red	5	0	0	0			16	37				
Brownsville	Rio Grande	4	9	0	18	2	6	28	103				
Laredo	Rio Grande	6	26	0	16	11	0	38	82	7	14	29	61
El Paso	Rio Grande	14	8	<1	0	6	15	25	109	2	0	14	0
Alamosa	Rio Grande	3	0	18	0	7	0	41	100				
Ruliff	Sabine	0	15	0	7	11	19	427	477				
SOUTHWEST REGION													
Cedar Hill	Animas	20	14	34	34	25	36	79	199	6	17	28	68
Preston	Bear									6	0	25	69
Yuma	Colorado	5	3	0	0	< 1	7	14	32				
Parker Dam	Colorado	11	0	0	62	7	0	31	48	12	0	30	0
Boulder City	Colorado	13	0	1	0	11	3	31	53				
Page	Colorado	12	49	1	40	14	24	44	98	8	0	39	23
Loma	Colorado	4	24	3	48	1	20	4	176	15	90	34	231
Dutch John	Green									6	0	35	0
Keno	Klamath	0	0	3	8	0	0	132	625	0	0	52	17
Vernalis	San Joaquin									5	36	24	36
Shiprock	San Juan					18	7	54	35	6	24	32	69
NORTHWEST REGION													
Fairbanks	Chena									0	0	11	71
Lewiston	Clearwater									4	0	44	97
Clatskanie	Columbia	0	0	115	145	0	0	825	862	7	0	251	265
Bonneville	Columbia	0	0	215	303	9	0	3,363	843				
McNary Dam	Columbia	0	0	360	296	7	0	3,527	1,532				
Pasco	Columbia	0	0	362	195	9	0	8,545	2,945	9	0	950	2,276
Wenatchee	Columbia	0	0	0	0	9	0	66	88	8	0	25	0
Albeni Falls Dam	Pend Oreille									7	0	35	13
Wawawai	Snake	13	0	38	0	9	0	90	304	11	0	41	71
Payette	Snake									12	0	31	26
Richland	Yakima	0	6	0	12	9	0	63	261				

[a] D, dissolved solids.
S, suspended solids.

In figure 2 (D), the alpha radioactivity on the suspended and dissolved solids as solids quality in each instance shows irregular patterns of rise and fall which seem independent of runoff patterns. Where suspended solids are involved, engineering and construction activities in which quantities of fresh earth are exposed to erosion could well account for some of these changes.

Gross radioactivity on individual samples at single stations

The usefulness of solids quality has been demonstrated in reducing the uncertainties that sometimes arise when water quality has been considered without interpretation. During periods of heavy runoff, water quality can vary enormously. Questions may arise as to whether there is radiological contamination. By computing the solids quality, the problem, if there is one, and its magnitude can be determined. In parts of the Southwest, erosion is a significant process in rainfall and may cause very high turbidity in flowing waters or even cause mud flows. Such mud suspensions are received as samples and the analytical results only serve to point up the nature of the samples.

In table 6 no interpretation is offered in regard to radiological values at certain stations or on certain streams or tributaries. Each unusual value may be considered with respect to

the *U.S. Public Health Service Drinking Water Standards* (*6*). Radioactivity values as solids quality are useful and necessary as a screening device, after which the levels of specific radionuclides can be determined as the occasion warrants.

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Technical Notes

Survey of Therapeutic X-Ray Installations in Alabama

William T. Willis and *Edward Cowan* [1]

The Bureau of Environmental Health of the Alabama State Department of Public Health has completed a radiological health survey of all known therapeutic X-ray installations within the State. The 20 therapeutic units located in Jefferson County were surveyed independently by the Jefferson County Health Department and brought into full compliance with provisions of the Alabama regulations for control of radiation; these units are excluded from this report.

The survey consisted of a physical inspection of each X-ray therapy unit to determine compliance with all applicable provisions of the Alabama regulations for control of radiation. All of the items required by Alabama regulations are based upon the recommended requirements of the National Committee on Radiation Protection, as published in National Bureau of Standards Handbook 76, and are identical to the suggested State regulations for the control of radiation as prepared by the Council of State Governments. The inspections were performed over a period of 1 year by a technically trained team of one radiation physicist and one registered X-ray technician.

A total of 38 X-ray therapy units was surveyed. Table 1 shows the units by type of therapy and category of use. Almost three-fourths of the X-ray therapy units are used in private medical practice.

Table 1. Number of units surveyed by type therapy and category of use

Type therapy	Category of use	
	Hospital	Private practice
Superficial	4	18
Deep [a]	7	9

[a] "Deep therapy" now called "orthovoltage therapy" in the "Planning Guide for Radiologic Installations," edited by Wendell G. Scott (1966).

A geographical distribution by county shows that two-thirds of the 38 therapy units are located in four counties, and that the remaining units are distributed in eight other counties. Excluding Jefferson County, therapeutic X-ray units are available in twelve of the remaining 66 counties; thus 54 counties have no X-ray therapy units. The distribution of units by county is shown in table 2.

Table 2. Distribution of therapy units by counties

County	Number of units
Montgomery	10
Mobile	6
Etowah	5
Tuscaloosa	3
Chambers	2
Morgan	2
Houston	2
Lauderdale	2
Calhoun	2
Madison	2
Randolph	1
Dallas	1
Total	38

Using the workload value of 4,000 milliampere-minutes/week found in the National Bureau of Standards Handbook 76 as the basis

[1] Mr. Willis is director and Mr. Cowan, assistant director, Division of Radiological Health, Bureau of Environmental Health, Alabama Department of Public Health, Montgomery, Ala.

for shielding calculations, the superficial therapy units in Alabama have very low workloads. It can be seen in table 3 that three-fourths of the units have a workload of only one-fourth the 4,000 milliampere-minutes/week used in Handbook 76.

Table 3. Workloads of superficial therapy units

Milliampere-minutes/week	Number of units
0 to 500	8
500 to 1,000	5
1,000 to 1,500	2
1,500 and above	3
Workload unknown	4

Using the National Bureau of Standards Handbook 76 figure of 40,000 milliampere-minutes/week as the basis for shielding calculations for deep X-ray therapy units, the deep X-ray therapy units in Alabama have relatively lower workloads than the State's superficial therapy units. Table 4 illustrates that the majority of the units have very small workloads; in fact, over one-half of the deep therapy units have a workload less than 3 percent of the National Bureau of Standards Handbook 76 value.

Table 4. Workloads of deep therapy units

Milliampere-minutes/week	Number of units
0 to 1,000	8
1,000 to 2,000	4
2,000 and above	3
Workload unknown	1

All of the therapy units were found to be in full compliance with 9 of the 14 required items. Almost all of the required items were related to physical aspects of the therapy units. The specific items inspected and found to be in compliance were: (1) therapeutic tube housing, (2) filters secure in place, (3) tube alignment, (4) tube housing stability, (5) timer provided, (6) timer terminates exposure, (7) tube "on" indicator, (8) adequate operator protection, and (9) patient observation.

Eighty-four percent of the 38 therapy units were found to be in noncompliance with one or more of the remaining five required items. These required items are interlocks provided (63 percent in noncompliance), interlocks functioning (8 percent in noncompliance), shielding adequate (11 per cent in noncompliance), radiation caution signs properly displayed (84 percent in noncompliance) and film badges provided (37 percent in noncompliance).

All X-ray therapy units should be provided with interlocks so that when any door of the treatment room is opened, either the unit shuts off automatically, or the radiation level within the room is reduced to a level of not more than 2 milliroentgens per hour. It is important to note that only units operating at 60 kVp and below are excepted from this requirement. This means that superficial therapy units operating above 60 kVp are governed by this requirement as well as deep therapy units. Several physicians thought that the installation of interlocks for superficial units would serve no useful purpose. Explanations given for this position were: (1) normally, the physician personally observes the patient and controls the area during treatment; (2) any interruption of treatment which necessitates entering the treatment room can be performed easily by turning off the unit from the control panel; (3) superficial units operate at low energies, generally from 60 to 70 kilovolts; and (4) most treatments are made with small diameter collimators. Probably as a reflection of this attitude toward interlocks, 17 superficial units were in noncompliance while only 7 deep units were found to be in noncompliance with this item.

Interlocks should be functioning properly in order to accomplish their purpose. Fourteen installations had interlocks and only one of these was found to be in noncompliance with this item.

Shielding adequacy requires that all wall, floor, and ceiling areas that can be struck by the primary beam, plus a border of 1 foot, be provided with primary protective barriers. All other wall, floor, and ceiling areas should be provided with secondary barriers. Both primary and secondary protective barriers must be sufficient to reduce the incident radiation to acceptable levels in unrestricted areas. Direct radiation measurements were taken during the survey to determine the adequacy of shielding. Using these actual radiation measurements, shielding computations determined that only four of the 38 units were at installations with insufficient shielding.

Each X-ray installation should be conspicuously posted with a warning sign which cautions that the treatment area is a radiation area. Eighty-four percent of all therapy units were found to be in noncompliance with this requirement. The item presents little difficulty as it can be corrected more easily than any of the other items of noncompliance.

Thirty-seven percent of all therapy units were operated by persons who did not wear a film badge, and consequently could not determine their occupational radiation exposure. Every person who reasonably could be expected to receive an exposure of 25 milliroentgens per week should wear a personnel monitoring device. Fortunately, this requirement is relatively easy to correct.

Subsequent to the inspection of each therapy unit a letter from the State Health Officer advised all installations of the inspection results. If an installation was found to be in noncompliance the letter pointed out the deficiency for each item of noncompliance and made recommendations for compliance. When the items of noncompliance had been corrected, the State Department of Public Health was informed and a reinspection was conducted to verify each correction. Initially 11 therapy units were in full compliance and 12 months later 36 of 38 units (95 percent) were in full compliance with the regulations. The high degree of compliance occurred because the physicians voluntarily cooperated with the requests of the health department. Enforcement aspects of the regulations were deliberately deemphasized.

Summary and discussion

All known X-ray therapy units in the State have been inspected for compliance with Alabama regulations for control of radiation. A total of 38 therapy units were inspected. During 1 year, the number of therapy units in full compliance was increased from 11 to 36. Only four of the 38 therapy machines were located in installations with insufficient shielding. The extremely low work load of most therapy units is largely responsible for the high degree of compliance with the requirement of shielding. The requirement for interlocks for superficial therapy units generated considerable constructive criticism concerning the need for this regulation. The reluctance of physicians to accept the requirement of interlocks for superficial therapy units as necessary or useful indicates that the rationale for this item should be reevaluated. With the exception of the difficulties regarding the requirement of interlocks for superficial units, the inspection of all X-ray therapy installations was well received by the physicians. Success of the survey is attributed largely to physician cooperation rather than regulatory enforcement.

Radium Survey in Alabama

William T. Willis and *Edward Cowan* [1]

Incidents have occurred in several States involving ruptured radium sources at hospitals, physicians' offices, and in industry. Preventive measures to avoid a ruptured source are compelling when public health and other consequences of a rupture incident are considered. Decontamination costs are expensive; for example, one industry spent $250,000 for decontamination following the rupture of a radium capsule. A source, however, need not rupture to allow the escape of radon and its daughter products. Small quantities of radon gas frequently leak from the source as a result of microscopic fissures. The leaking radon gas results in contamination, but perhaps more importantly, it serves as a warning sign that the source encapsulation has deteriorated, portending possible trouble of a more serious nature; namely gross rupture. The purpose of a radium survey is to detect leaking sources before a serious rupture occurs, and to detect contamination in order that contaminated areas are decontaminated before serious problems develop.

Radium sources in Alabama have never been licensed, inspected, or subjected to State or Federal regulatory requirements prior to 1965. Health departments in other States have found significant numbers of facilities with leaking radium sources and contaminated equipment (*1*).

During 1964, the Jefferson County Health Department surveyed all radium sources in Jefferson County to determine the kind and degree of existing associated radiation hazards. Among conditions and practices found to be inadequate, leaking radium sources were numerous. Four of the ten facilities surveyed had one or more leaking radium sources and three of the four were significantly contaminated. Physicians and representatives of industry viewed the survey as a service and showed their acceptance by responding favorably to the Jefferson County Health Department recommendations (*1*).

The Alabama State Department of Public Health was encouraged by the accomplishments of the Jefferson County survey and conducted a similar survey for all radium users in the remaining counties of the State. The survey had three objectives:

1. to test all know sources of radium for leakage,
2. to determine the presence of contamination, and
3. to train staff personnel in conducting inspections of radioactive materials.

Thirty-seven facilities were registered as having radium on their premises. The State Health Officer wrote each facility to explain the nature and purpose of the survey emphasizing that participation in the survey and compliance with Department recommendations would be entirely voluntary. Post cards were

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enclosed to notify the Department of intended participation. Response to letters exceeded expectations:

Letters to radium facilities	37
Response from facilities in 1 month	37
Wanted to participate	28
Did not want to participate	2
Did not possess radium	7

The two nonparticipating facilities asked to be included after a second letter further explained the intent of the survey.

Bureau of Environmental Health personnel began the survey in April 1965, by making appointments with the users for all visits. The "jar-test method," which enables detection of alpha particles emitted by radon daughters, was used for leak testing the sources (*2*). A radium source is placed into a small glass jar and sealed with a screw-on cap. After the source has remained in the closed jar for 24 hours, the jar lid is removed. The jar lid is turned over and monitored with a gas-flow proportional counter. The relative absence of alpha particles indicates that the source is not leaking and is not contaminated by a source that is leaking. The survey is concluded if the source is found not to be leaking. If the source is found to be leaking or contaminated, additional monitoring is performed on the storage container, equipment, and the premises to determine the extent of contamination. At the present time there are no uniform standards that differentiate between a leaking and nonleaking source. The sensitivity of the testing system would justify the selection of approximately 100 to 1,000 counts per minute as a standard. In the absence of a recommended uniform standard, 1,000 alpha-particle counts per minute was chosen to indicate a leaking source for this survey.

Of the 30 users in Alabama, 9 were hospitals, 18 private physicians, and 3 industrial users. Thus, radium is used in Alabama primarily in the field of medicine and by private physicians. The 30 facilities possessed a total of 2,638 milligrams of radium of which 495 milligrams were either leaking or contaminated. Thirteen of the 30 facilities had one or more leaking sources and all but one of these sources were possessed by private physicians.

A commercial firm had performed leak tests of radium sources at 7 facilities within the last 2 years. If routine leak testing is of value, one would expect to find fewer leaking sources among those previously leak tested. Of the 7 facilities which had undergone testing within the past 2 years, only one was found to have leaking sources, whereas of the 23 facilities which had not undergone testing previously, 12 were found to have leaking sources. This points out the importance of periodic leak testing.

Radium sources are either privately owned or rented. A high percentage of owned sources had never been leak tested; therefore one would expect to find more leaking sources among those privately owned than among those rented. Of the 20 sources which were privately owned, 11 were found to be leaking, whereas only 2 of the 11 rented sources were leaking.

By using 1,000 alpha-particle counts per minute as the minimum standard to indicate a leaking source, it was thought that some of the test results might group around the standard creating borderline situations. This was not the case. Table 1 shows that there were no marginally leaking sources and that the largest percent of leaking sources were, in fact, heavily leaking. Wherever a leaking radium source was found, contamination of the immediate area was also found. Oddly enough, contamination was also present at 5 facilities which did not possess a leaking source. This finding supports the proposition that sources can leak intermittently. It is interesting to note that generally, the contamination was confined quite closely to the area of the storage container and in no case was it wide-spread. This fact minimized the contamination hazard and made decontamination easy.

Following the survey, a letter was sent to each facility stating the survey findings and, when applicable, making recommendations concerning leaking sources and contaminated areas. Decontamination was performed at each facility where contamination was found. Decontamination procedures in these cases involved only a simple process of washing and scrubbing, since no case was found where contamination was serious enough to justify the procurement of decontamination services from

a commercial firm. Leaking sources at all but one facility were either disposed of through an arrangement with the U.S. Public Health Service or re-encapsulated. As a result of the survey 212 milligrams of radium were disposed of by private physicians and 45 milligrams by hospitals. An additional 105 milligrams was re-encapsulated for facilities that did not wish to dispose of the radium.

Table 1. Magnitude of radium leaking sources

Number of facilities	Alpha particle radioactivity range (counts per minute)
2	1,000- 25,000
4	25,000- 50,000
0	50,000- 75,000
7	75,000-100,000

Summary

Of the 30 facilities using radium in Alabama, 13 had one or more leaking sources. Twelve facilities fully complied with recommendations for disposal or re-encapsulation. Recommendations were made for six facilities to decontaminate, and all six complied. Only one radium user had not complied with our recommendations, and this is the result of indecision over what action to take rather than a refusal to act. The reception given the survey team by physicians and the voluntary compliance by physicians with recommendations of the Bureau of Environmental Health was excellent.

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1966	September 1967

1. Pasteurized Milk Network September 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for large scale programs. Experience derived from this earlier network led to the activation of the Pasteurized Milk Network (PMN) with stations selected to provide continuing nationwide measurement of radionuclide levels in pasteurized milk through sampling of major milk production and consumption areas and to provide information on concentration levels and trends from which local, State, and Federal agencies can determine the need for further investigation and/or cor-

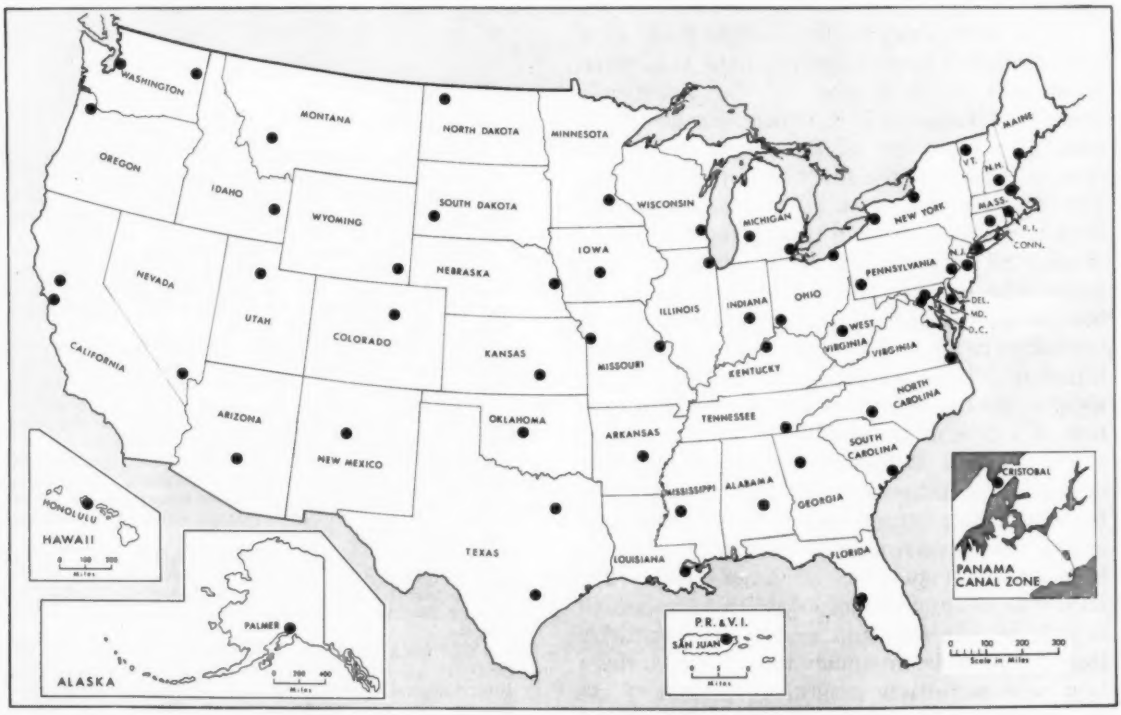

Figure 1. Pasteurized Milk Network sampling locations

rective action for the protection of public health. The present network consists of 63 stations with at least one in every State, the Canal Zone, Puerto Rico, and Washington, D.C. (figure 1).

Sampling procedures

Samples are collected with the cooperation of State and local milk sanitation authorities. According to established procedures, the sample at each station is a composite of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week, except for brief periods of known or suspected increased fallout when samples were taken twice a week.

After compositing, samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-ray scintillation spectrometry. After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically to determine strontium–89 and strontium–90. With all such measurements, there is an inherent statistical variation. For the low radionuclide levels usually observed in milk and other environmental samples, this variation on a percentage basis is relatively high. It depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma-ray spectrometry and 30 to 50 minutes for beta-particle determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined here as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Gamma-ray analyses are made within 3 to 6 days after sample collection and radiochemical analysis results are normally available 4 to 5 weeks after the weekly samples are received by the laboratories. Short-lived radionuclide concentrations are corrected back to the date of collection.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10
Iodine-131	<100	10	≥ 100	10
Cesium-137	<100	10	≥ 100	10
Barium-140	<100	10	≥ 100	10

[a] Two standard deviations.

Data presentation

The results for September 1967, and the third quarter of 1967, are presented in figure 2. If radionuclide levels were below minimum detectable concentrations, averages were calculated using one-half the minimum detectable values; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels. Values for iodine–131 and barium–140 were below minimum detectable concentrations during the period covered in this report. Values for strontium–89, except for Wichita, Kans. (5 pCi/liter), were also below minimum detectable concentrations. Results for these three radionuclides have not been included in table 2.

Table 2. Average concentrations of radionuclides in pasteurized milk for the third quarter 1967 and September 1967

Sampling location		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Third quarter 1967	Sept 1967	Third quarter 1967	Sept 1967
Ala:	Montgomery	9	11	15	15
Alaska:	Palmer	6	6	25	25
Ariz:	Phoenix	2	1	< 5	< 5
Ark:	Little Rock	24	23	20	20
Calif:	Sacramento	4	3	5	10
	San Francisco	3	2	5	5
C. Z:	Cristobal	4	3	15	15
Colo:	Denver	7	6	10	10
Conn:	Hartford	10	9	20	15
Del:	Wilmington	11	11	15	10
D. C:	Washington	10	10	10	10
Fla:	Tampa	8	7	80	80
Ga:	Atlanta	16	14	25	25
Hawaii:	Honolulu	4	3	10	10
Idaho:	Idaho Falls	6	5	10	10
Ill:	Chicago	8	8	15	15
Ind:	Indianapolis	8	6	10	10
Iowa:	Des Moines	8	6	10	5
Kans:	Wichita	8	6	10	10
Ky:	Louisville	13	12	10	10
La:	New Orleans	24	24	30	25
Maine:	Portland	13	12	35	30
Md:	Baltimore	11	11	10	10
Mass:	Boston	13	12	30	25
Mich:	Detroit	9	8	15	15
	Grand Rapid	10	8	15	15
Minn:	Minneapolis	13	12	15	15
Miss:	Jackson	19	18	15	20
Mo:	Kansas City	11	9	5	< 5
	St. Louis	10	11	5	10
Mont:	Helena	6	6	10	15
Nebr:	Omaha	10	9	10	5
Nev:	Las Vegas	2	2	5	< 5
N. H:	Manchester	15	13	45	40
N. J:	Trenton	10	10	10	10
N. Mex:	Albuquerque	3	3	5	< 5
N. Y:	Buffalo	8	7	15	15
	New York City	11	11	15	10
	Syracuse	9	9	15	20
N. C:	Charlotte	17	16	20	15
N. Dak:	Minot	11	10	10	10
Ohio:	Cincinnati	9	7	10	10
	Cleveland	10	8	15	10
Okla:	Oklahoma City	11	12	10	5
Ore:	Portland	8	8	20	15
Pa:	Philadelphia	10	9	10	10
	Pittsburgh	13	10	15	15
P. R:	San Juan	5	4	15	15
R. I:	Providence	12	12	30	25
S. C:	Charleston	16	16	35	30
S. Dak:	Rapid City	13	9	15	15
Tenn:	Chattanooga	17	16	20	15
	Memphis	14	14	10	5
Tex:	Austin	3	3	10	< 5
	Dallas	10	7	10	15
Utah:	Salt Lake City	6	4	15	15
Vt:	Burlington	11	9	20	15
Va:	Norfolk	13	12	15	10
Wash:	Seattle	10	10	35	30
	Spokane	9	8	15	10
W. Va:	Charleston	12	9	10	10
Wis:	Milwaukee	7	6	15	15
Wyo:	Laramie	5	6	10	10
Network average		9.9	9.1	15	15

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for September 1966, and April through September 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations at PMN stations, September 1966 and April–September 1967

Strontium-90 (pCi/liter)	Number of stations [a]						
	1966	1967					
	Sept	April	May	June	July	Aug	Sept
Under 10	21(33)	25(40)	25(40)	27(43)	25(40)	35(55)	37(59)
10-19	37(59)	34(54)	35(55)	34(54)	35(55)	26(42)	24(38)
20-29	5(8)	4(6)	3(5)	2(3)	3(5)	2(3)	2(3)
30-39	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

[a] Percentage of stations shown in parentheses.

Table 4. Frequency distribution, cesium-137 concentrations at PMN stations, September 1966 and April–September 1967

Cesium-137 (pCi/liter)	Number of stations [a]						
	1966	1967					
	Sept	April	May	June	July	Aug	Sept
Under 50	61(97)	62(98)	61(97)	61(97)	61(97)	61(97)	62(98)
50-99	1(1.5)	1(2)	2(3)	2(3)	2(3)	2(3)	1(2)
100-149	1(1.5)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

[a] Percentage of stations shown in parentheses.

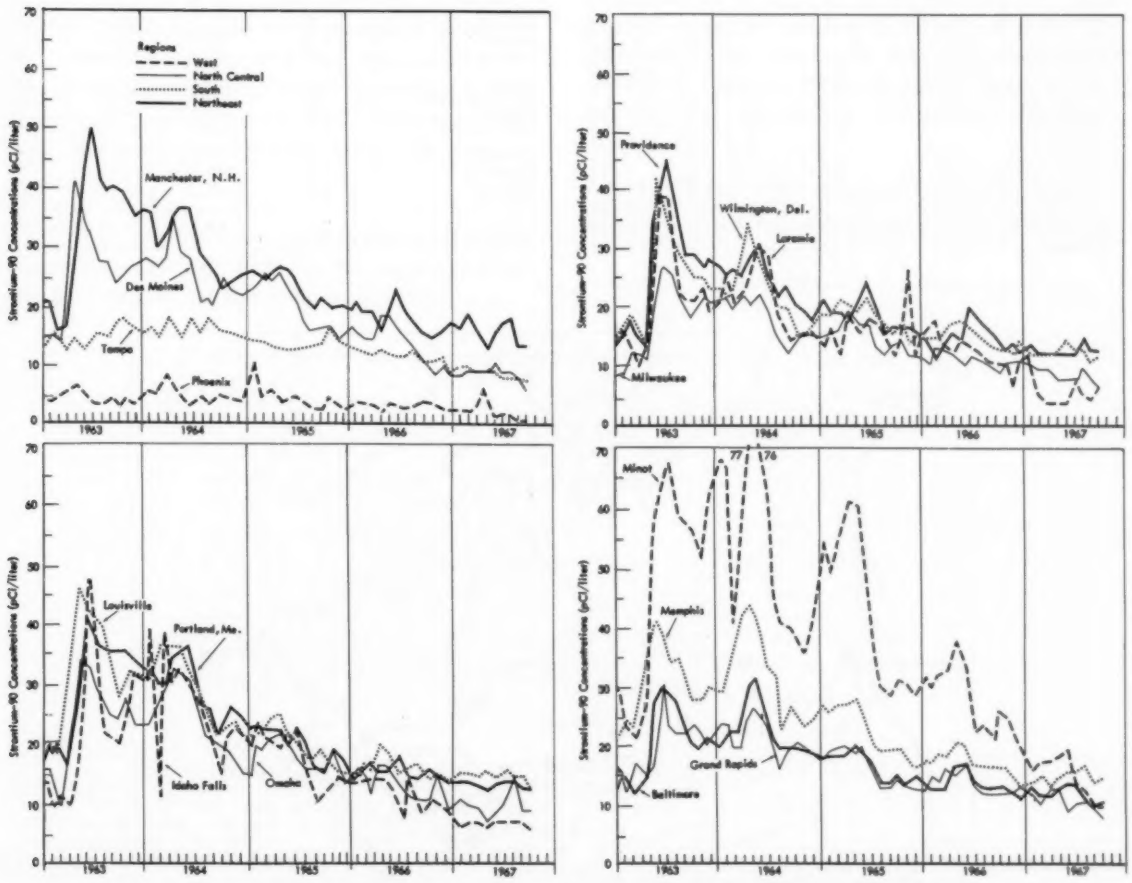

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–September 1967

2. Canadian Milk Network September 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The September 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from November 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, September 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.07	1.3	9.5	19
Edmonton	1.13	1.4	5.3	28
Ft. William	1.09	1.5	13.9	30
Fredericton	1.10	1.4	17.8	30
Halifax	1.14	1.4	14.5	27
Montreal	1.09	1.4	8.8	18
Ottawa	1.12	1.4	6.6	18
Quebec	1.12	1.4	14.1	30
Regina	1.12	1.4	7.9	17
St. John's, Nfld.	1.09	1.5	25.5	53
Saskatoon	1.10	1.4	8.0	14
Sault Ste. Marie	1.09	1.5	13.6	29
Toronto	1.13	1.4	5.9	16
Vancouver	1.20	1.4	15.0	54
Windsor	1.12	1.4	5.4	15
Winnipeg	1.10	1.5	5.4	25
Average	1.11	1.4	11.1	26

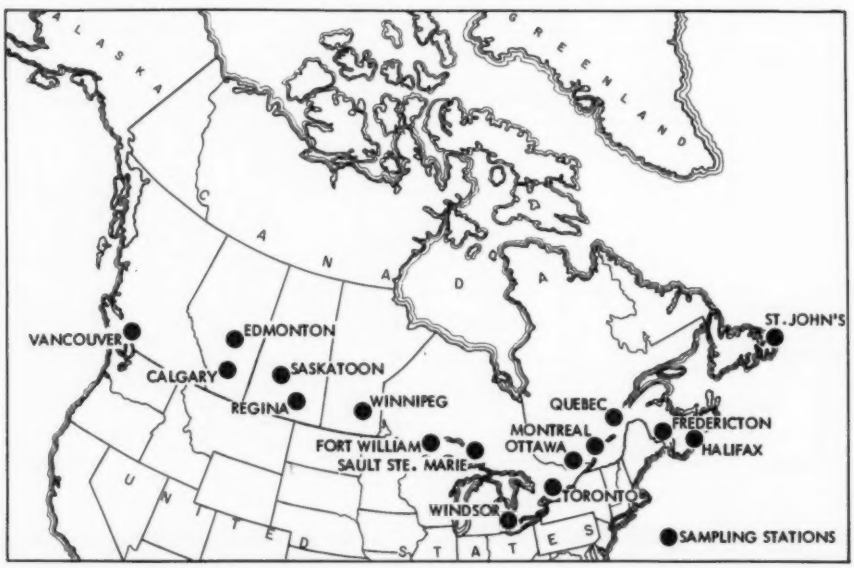

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program September 1967

Pan American Health Organization and
U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO-member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Table 6 presents stable potassium, strontium–90, cesium–137, and barium–140 monthly average concentrations for September 1967.

Figure 4. Pan American Milk Sampling Program locations

Table 6. Stable element and radionuclide concentrations in PAHO milk[a] September 1967

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Colombia: Bogota	1	1.3	1	< 5	<10
Ecuador: Guayaquil	1	1.6	< 1	10	<10
Jamaica: Montego Bay	1	1.4	12	365	10
Venezuela: Caracas	[b]1	1.5	2	10	<10
	1	1.5	3	< 5	15
Canal Zone: Cristobal [c]	4	1.5	3	16	<10
Puerto Rico: San Juan [c]	4	1.6	4	14	<10

[a] Strontium-89 was less than 5 pCi/liter and iodine-131 was less than 10 pCi/liter for all samples.
[b] August 1967 data. Sample delayed in transit.
[c] For comparison purposes, the radionuclide concentrations from the Pasteurized Milk Network at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

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(*1*) PUBLIC HEALTH SERVICE. Summary of results from the raw milk sampling program, June 1957–April 1963. Radiol Health Data 4:511–523 (October 1963).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmentalal surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. The following is a summary of previously covered State programs, their reporting periods, and issue of appearance.

State milk network	Period reported	Last presented
California	April–June 1967	December 1967
Connecticut	April–June 1967	November 1967
Indiana	April–June 1967	November 1967
Iowa	April–June 1967	November 1967
Michigan	April–June 1967	November 1967
Minnesota	April–June 1967	November 1967
New York	April–June 1967	November 1967
Oregon	April–June 1967	December 1967
Pennsylvania	April–June 1967	November 1967
Washington	April–June 1967	December 1967

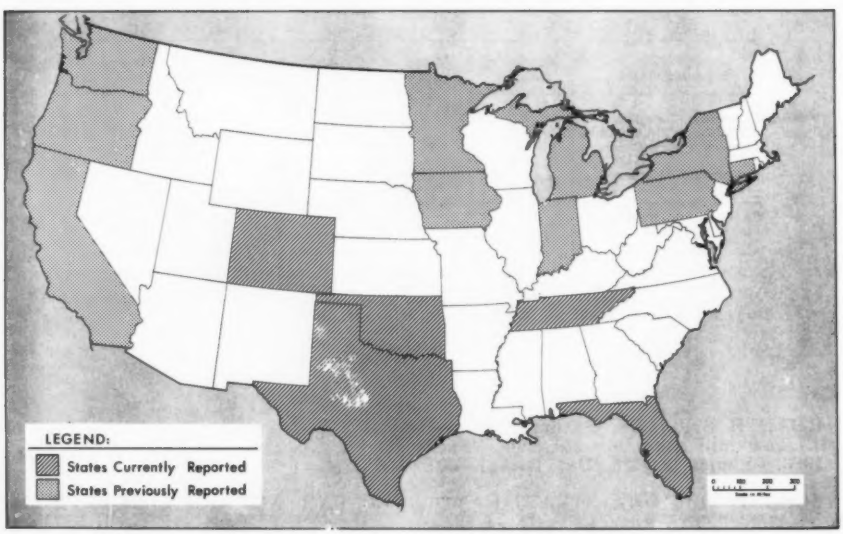

Figure 1. Reported State milk programs

1. Colorado Milk Network July–September 1967

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeastern, southeastern, western Colorado and eastern Utah. Areas of the State presently sampled are western, south central, northeastern, southeastern and eastern Colorado (including northwestern Kansas). Colorado milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, barium–140, cesium–137, and potassium by gamma-ray spectroscopy. The measurement system previously reported (*1*) has been adapted to utilize a 4- by 5-inch NaI crystal shielded by a lead-lined bank safe.

Minimum detectable amounts at the 2 standard deviation counting error equivalent are: 10 pCi/liter for iodine–131 and cesium–137; 15 pCi/liter for barium-lanthanum–140; and 0.2 g/liter for potassium.

Table 1 gives results of the measurement of radionuclides in milk collected from July through September 1967. Barium-lanthanum–140 was not detected during this period.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

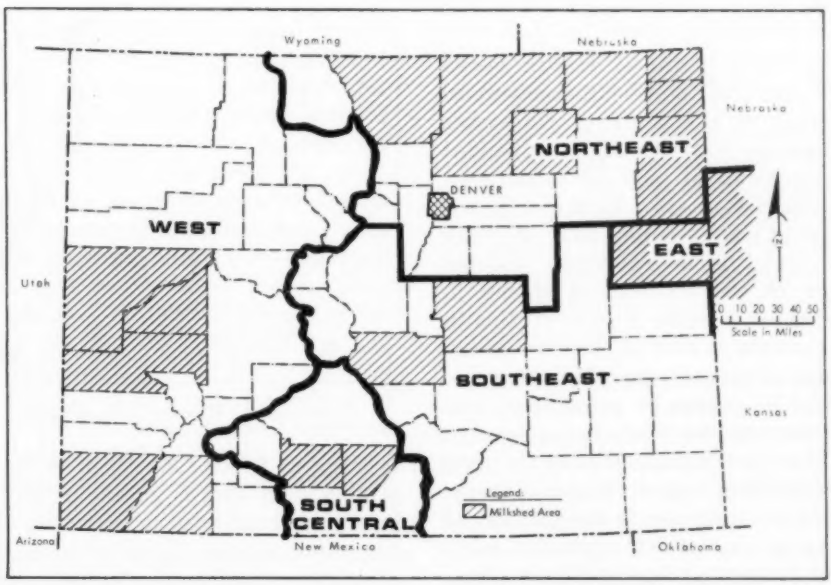

Figure 2. Colorado milk sampling stations

Table 1. Radionuclides in Colorado milk, July–September 1967

Date of sampling		Area sampled [a]	Number of samples analyzed	Number of samples containing detectable radionuclides [b]	Concentration of detectable radionuclides (pCi/liter)		Concentration of detectable radionuclides (g/liter)
					Iodine-131	Cesium-137	Potassium
July	1	NE	1	0	ND	ND	1.6
	1	NE	1	1	12	36	1.5
	1	NE	1	1	ND	32	1.4
July	28	SE	1	0	ND	ND	1.6
August	27	SE	1	1	ND	18	1.7
September	19	SE	1	0	ND	ND	1.4
	27	SE	1	1	ND	18	1.7
August	19	SC	1	0	ND	ND	1.4
	26	SC	1	0	ND	ND	1.7
September	26	SC	1	0	ND	ND	1.7
July	20	W	1	1	ND	16	1.4
August	10	W	1	1	20	51	1.9
	10	W	1	0	ND	ND	1.2
	16	W	1	1	24	ND	1.4

[a] NE—Northeastern Colorado
SE—Southeastern Colorado
SC—South Central Colorado
W—Western Colorado

[b] Minimum detectable activity is taken as equal to or greater than the 2-standard counting error equivalent and for the two radionuclides given is 10 pCi/liter.
ND, nondetectable.

2. Florida Milk Network July–September 1967

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, cesium–137, barium–140 and potassium, in addition to iodine–131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where

Figure 3. Florida milk sampling areas

Table 2. Stable element and radionuclide concentrations in Florida raw milk, July–September 1967

Sampling location	Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)			Potassium (g/liter)		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Western	20	17	18	<20	<20	<20	31	23	35	ND	32	ND	1.6	1.5	1.5
Northern	23	20	19	<20	<20	<20	37	56	33	ND	24	23	1.6	1.5	1.5
Northeastern	13	13	NA	<20	<20	<20	89	193	122	ND	39	ND	1.6	1.4	1.4
Central	9	21	NA	<20	29	<20	77	157	84	ND	25	ND	1.3	1.7	1.3
Tampa Bay Area	10	10	10	<20	<20	<20	85	125	106	ND	ND	29	1.4	1.4	1.5
Southeastern	9	8	10	<20	<20	<20	113	121	123	30	27	ND	1.4	1.6	1.5
Average	14	15	14	<20	<20	<20	72	113	84	5	25	9	1.5	1.5	1.4

ND, nondetectable.
NA, no analysis

locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominately purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.* (*2*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*3*).

Radionuclide concentration levels for July through September 1967, are presented in table 2. Strontium–89 analyses has been discontinued since 1965 due to extremely low levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	October 1966
January–June 1967 and summary for 1966	October 1967

3. Oklahoma Milk Network July–September 1967

Oklahoma State Department of Health [1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. Of the ten milksheds in the State of Oklahoma, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 4, the coincidence is satisfactory for surveillance purposes.

Analytical method

The method of analysis is similar to that recently published by the U.S. Public Health Service (*4*) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were summarized earlier (*5*).

Results and discussion

Due to instrumental difficulties, only the samples collected on September 1 were analyzed. The concentrations of iodine–131 found in Oklahoma milk were less than the minimum detectable concentration of 3 pCi/liter. Cesium–137 concentrations were <10 pCi/liter for the Oklahoma City, Tulsa and Ardmore samples and 13 pCi/liter for the Enid and Lawton samples.

[1] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

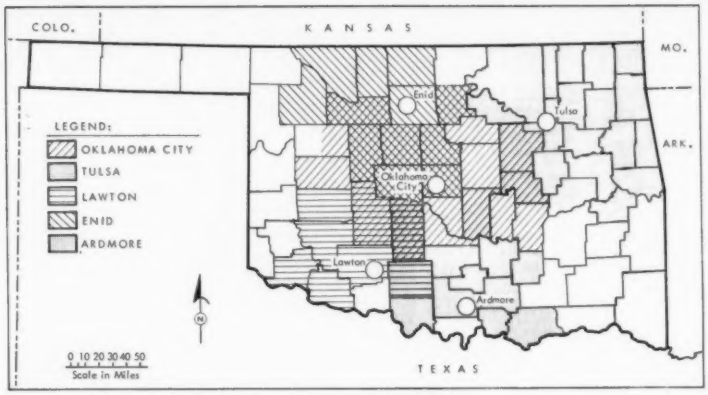

Figure 4. Oklahoma milkshed sampling areas

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

4. Tennessee Milk Network July–September 1967

Division of Preventable Diseases
Department of Public Health
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 5). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of milk is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for potassium–40, iodine–131, cesium–137, and barium–140, using a 3½-liter sample. After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calicum and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a crosscheck between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 3 for the period of July through September 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

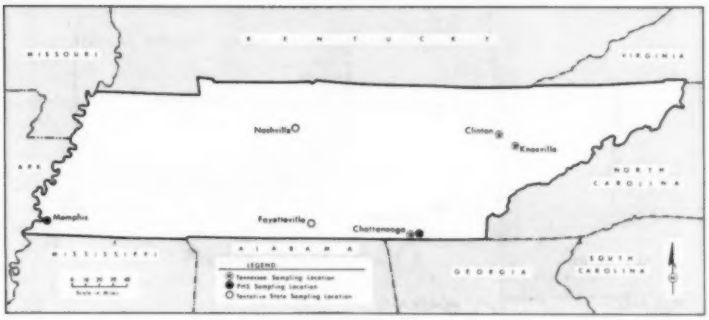

Figure 5. Tennessee pasteurized milk sampling stations

Table 3. Radionuclides in Tennessee pasteurized milk, July–September 1967

Location	Month 1967	Concentration (g/liter)	Radionuclide concentration (pCi/liter)				
		Potassium	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Chattanooga	July	1.4	<5	20	10	22	<5
	August	1.4	<5	16	13	19	<5
	September	1.4	<5	23	<8	18	<5
Clinton	July	1.4	<5	18	<8	19	<5
	August	1.5	<5	18	11	36	<5
	September	1.3	<5	17	8	24	<5
Knoxville	July	1.4	<5	16	15	21	<5
	August	1.4	<5	16	13	12	6
	September	1.4	<5	15	<8	13	<5

5. Texas Milk Network July–September 1967

Texas State Department of Health [2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 6 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium–40, iodine–131, cesium–137 and barium–140 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium-iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5-liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium–40, strontium–90 and cesium–137 results by station and month for July through September 1967 are presented in table 4. During this time, the iodine–131, and barium–140

[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

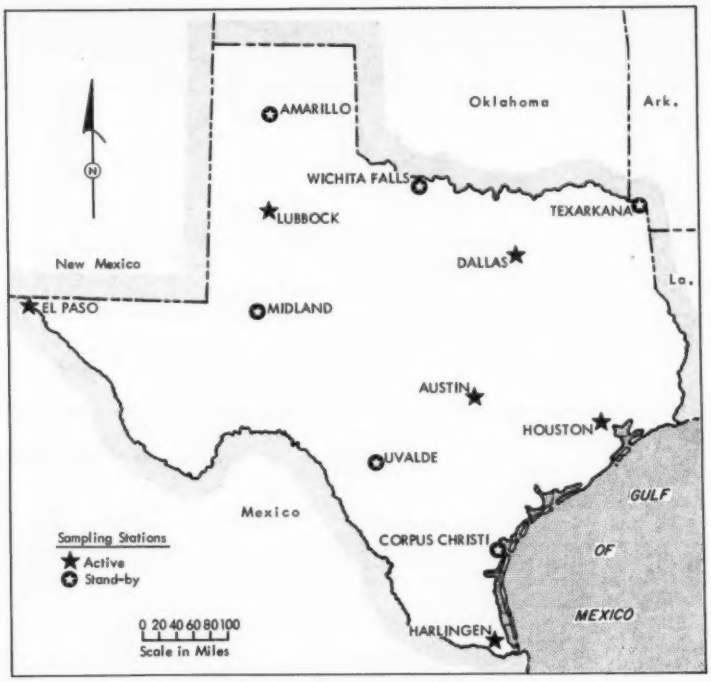

Figure 6. Texas milk sampling stations

concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through September 1967 is presented in figure 7.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*7*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

Table 4. Radionuclide concentrations in Texas raw milk network July–September 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Austin	1,300	1,320	1,360	3	3	4	5	3	5
Fort Worth	1,260	1,330	1,290	7	6	5	10	5	ND
El Paso	1,340	1,310	NA	2	ND	NA	<5	ND	NA
Harlingen	1,320	1,310	1,350	1	1	2	<5	ND	ND
Houston	1,360	1,290	1,270	6	9	10	15	15	5
Lubbock	1,310	1,310	1,250	5	3	3	5	5	5
San Antonio	1,300	1,290	NA	2	2	NA	5	5	NA
Average	1,310	1,310	1,300	4	4	5	7	7	5

NA, no analysis.
ND, nondetectable.

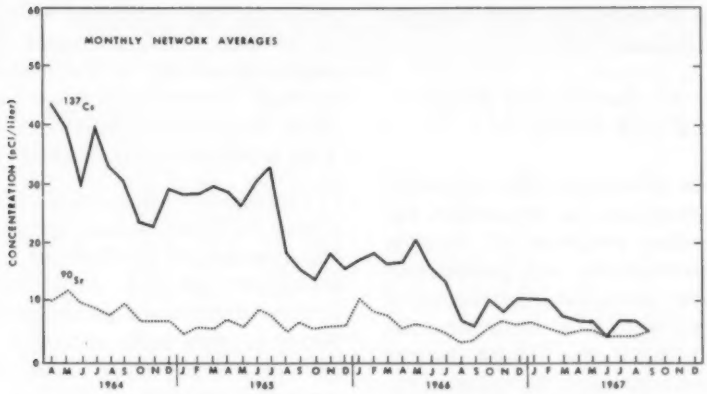

Figure 7. Radionuclide concentrations in Texas milk April 1964–September 1967

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(*1*) COLORADO STATE DEPARTMENT OF PUBLIC HEALTH, OCCUPATIONAL AND RADIOLOGICAL HEALTH DIVISION. Colorado Milk Network, October–December 1964 and summary 1962–1964. Rad Health Data 6:202–204 (April 1965).

(*2*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium–90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*3*) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

(*4*) PORTER, C. and M. W. CARTER. Field method for rapid collection of iodine–131 from milk. Public Health Rep 80:453–456 (May 1965).

(*5*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, October–December 1966. Radiol Health Data 8:203–204 (April 1967).

(*6*) PORTER, C. and B. KAHN. Improved determination of strontium–90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

(*7*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nation-wide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	January–February 1967	October 1967
Connecticut Standard Diet	January–June 1967	November 1967
Tri-City Diet, HASL	August–December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples April–June 1967

National Center for Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of July 1964, its scope had increased to boarding schools or institutions in 51 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied

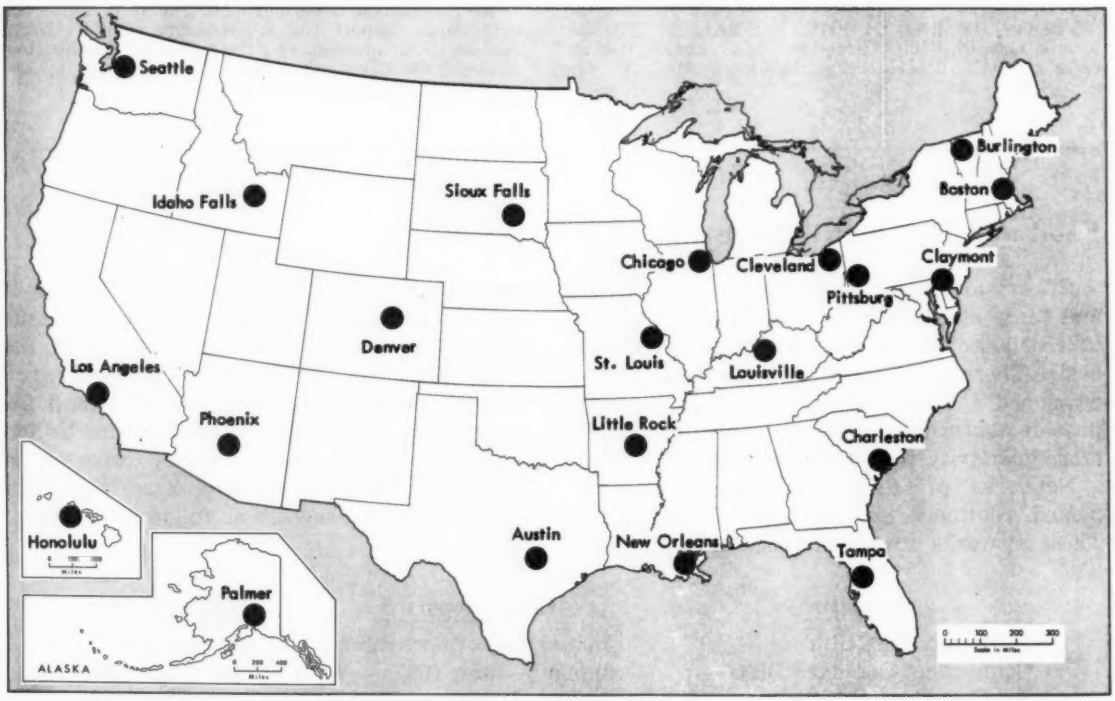

Figure 1. Institutional diet sampling locations as of July 1965

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9-12 years of age), April–June 1967

Location of institution	1967 month	Total weight (kg/day)	Calcium		Potassium		Strontium-89		Strontium-90		Cesium-137		Radium-226	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	April	1.31	0.7	0.9	2.2	2.9	<5	5	9	12	25	35	0.5	0.7
	May	1.22	0.6	0.7	2.0	2.4	<5	5	7	9	25	30	1.1	1.3
	June	1.63	0.4	0.7	1.3	2.1	<5	5	5	8	15	25	0.9	1.5
Ariz: Phoenix	April	1.61	0.8	1.3	1.7	2.7	<5	5	7	11	15	25	0.7	1.1
	May	1.88	0.6	1.1	1.4	2.6	<5	5	4	8	10	20	0.7	1.3
	June	1.60	0.7	1.1	1.7	2.7	5	10	7	11	10	15	0.7	1.1
Ark: Little Rock	April	1.38	0.5	0.7	1.4	1.9	NA	NA	10	14	20	30	0.9	1.2
	May	1.38	0.6	0.8	1.5	2.1	NA	NA	14	19	15	20	0.9	1.2
	June	1.11	0.5	0.6	1.6	1.8	NA	NA	13	14	20	20	1.0	1.1
Calif: Los Angeles	April	2.12	0.8	1.7	1.7	3.6	<5	5	4	8	15	30	0.7	1.5
	May	1.85	0.8	1.5	1.7	3.1	<5	5	5	9	10	20	0.6	1.1
	June	2.13	1.1	2.3	1.5	3.2	<5	5	5	11	10	20	0.4	0.9
Colo: Denver	April	2.15	0.7	1.5	1.6	3.4	<5	5	7	15	15	30	0.4	0.9
	May	2.08	0.6	1.2	1.8	3.7	<5	5	7	15	15	30	0.8	1.7
	June	1.98	0.8	1.6	1.6	3.2	<5	5	6	12	25	50	0.8	1.6
Del: Wilmington	April	2.19	0.7	1.5	1.9	4.2	<5	5	9	20	10	20	0.6	1.3
	May	2.11	0.7	1.5	1.9	4.0	<5	5	8	17	15	30	0.6	1.3
	June	2.34	0.8	1.9	1.7	4.0	<5	5	12	28	30	70	1.1	2.6
Fla: Tampa	April	2.05	0.5	1.0	1.7	3.5	NA	NA	7	14	35	70	1.5	3.1
	May	2.07	0.5	1.0	1.8	3.7	NA	NA	8	17	40	85	1.4	2.9
	June [a]	2.02	0.6	1.2	1.8	3.6	NA	NA	7	14	50	100	1.4	2.8
Hawaii: Honolulu	April	2.50	0.4	1.0	1.3	3.3	<5	5	4	10	15	35	0.7	1.8
	May	2.33	0.5	1.2	1.4	3.3	<5	5	3	7	15	35	0.6	1.4
	June	2.37	0.4	0.9	1.7	4.0	<5	5	2	5	25	60	0.4	0.9
Idaho: Idaho Falls	April [a]	2.09	0.8	1.7	1.9	4.0	<5	5	8	17	10	20	0.4	0.8
	May [a]	1.82	1.3	2.4	1.7	3.1	<5	5	7	13	20	35	0.9	1.6
	June [a]	1.56	1.0	1.6	1.8	2.8	<5	<2	[b]2	1	15	25	0.6	0.9
Ill: Chicago	April	1.54	0.6	0.9	1.7	2.6	<5	5	7	11	10	15	0.6	0.9
	May	1.95	0.8	1.6	1.6	3.1	<5	5	8	16	15	30	0.7	1.4
	June	1.59	0.7	1.1	1.6	2.5	<5	5	8	13	15	25	0.7	1.1
Ky: Louisville	April [a]	1.67	0.8	1.3	1.5	2.5	NA	NA	11	18	15	25	1.3	2.2
	May [a]	1.63	0.8	1.3	1.6	2.6	NA	NA	12	20	10	15	1.2	2.0
	June [a]	1.75	0.7	1.2	1.7	3.0	NA	NA	12	21	15	25	0.9	1.6
La: New Orleans	April	1.48	0.5	0.7	1.5	2.2	<5	5	12	18	15	20	0.7	1.0
	May	1.84	0.7	1.3	2.0	3.7	<5	5	14	26	55	100	1.2	2.0
	June	1.78	0.6	1.1	1.5	2.7	<5	5	10	18	20	35	1.2	2.1
Mass: Boston	April	1.80	0.7	1.3	1.6	2.9	<5	5	10	18	30	55	0.7	1.3
	May	1.52	0.9	1.4	1.6	2.4	<5	5	11	17	25	40	0.6	0.9
	June	1.50	0.8	1.2	1.7	2.6	<5	5	11	17	15	25	0.5	0.8
Mo: St. Louis	April	1.33	0.9	1.2	1.7	2.3	<5	5	11	15	10	15	0.5	0.7
	May	1.52	0.9	1.4	1.7	2.6	<5	5	15	23	15	25	0.6	0.9
	June	2.08	0.8	1.7	1.9	4.0	<5	5	14	29	10	20	1.0	2.1
Ohio: Cleveland	April	1.43	0.6	0.9	2.1	3.0	<5	5	7	10	10	15	0.6	0.9
	May	1.33	0.7	0.9	2.0	2.7	<5	5	9	12	20	25	0.7	0.9
	June	1.48	0.7	1.0	2.1	3.1	<5	5	7	10	20	30	0.6	0.9
Pa: Pittsburgh	April [a]	2.22	0.6	1.3	1.5	3.3	<5	5	10	22	20	45	0.7	1.6
	May [a]	2.22	0.6	1.3	1.5	3.3	<5	5	7	16	10	20	0.6	1.3
	June [a]	2.20	0.6	1.3	1.6	3.5	<5	5	10	22	10	20	0.9	2.0
S. C: Charleston	April	1.36	0.6	0.8	1.4	1.9	<5	5	9	12	30	40	1.6	2.2
	May	1.44	0.7	1.0	1.5	2.2	<5	5	11	16	20	30	1.7	2.4
	June	1.96	0.6	1.2	1.4	2.7	<5	5	8	16	30	60	1.4	2.7
S. Dak: Sioux Falls	April	1.05	0.7	0.7	1.6	1.7	<5	5	6	6	15	15	0.6	0.6
	May	1.15	0.7	0.8	1.7	2.0	<5	5	8	9	20	25	0.7	0.8
	June	1.25	0.6	0.8	1.7	2.1	<5	5	6	8	15	20	1.0	1.3
Tex: Austin	April	1.69	0.6	1.0	1.3	2.2	NA	NA	5	8	10	15	0.8	1.4
	May	1.83	0.6	1.1	1.1	2.0	NA	NA	5	9	5	10	0.8	1.5
	June	1.76	0.6	1.1	1.4	2.5	NA	NA	5	9	15	25	0.7	1.2
Vt: Burlington	April	0.92	0.8	0.7	1.8	1.7	<5	5	13	12	15	15	0.5	0.5
	May	1.18	0.8	0.9	1.6	1.9	<5	5	11	13	20	25	0.6	0.7
	June	1.16	0.6	0.7	2.0	2.3	<5	5	8	9	15	15	0.6	0.7
Wash: Seattle	April [a]	1.59	0.7	1.1	1.9	3.0	<5	5	8	13	15	25	0.4	0.6
	May [a]	1.88	0.6	1.1	1.7	3.2	<5	5	11	21	35	65	1.0	1.9
	June [a]	1.83	0.6	1.1	1.6	2.9	<5	5	7	13	30	55	0.8	1.5
Institutional average	April	1.64	0.7	1.0	1.7	2.7	<5	5	8	13	20	30	0.7	1.2
	May	1.72	0.7	1.1	1.7	2.8	<5	5	9	14	20	35	0.8	1.5
	June	1.73	0.7	1.2	1.7	2.8	<5	5	8	14	20	30	0.8	1.6

[a] Since food samples were collected from two or more children who were over 12 years of age, data for this month were not used in institutional average.
[b] Less than 2 pCi/kg of strontium-90 was interpreted as 1 pCi/kg for the purpose of obtaining dietary intakes.
NA-no analysis
NOTE: Since iodine-131 and barium-140 were not detectable at most stations during the second quarter 1967 no provision was made for these nuclides in the table. The one exception is as follows: Iodine-131 was reported in May for Phoenix, Ariz (13 pCi/kg).

monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily food sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June, 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.70 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium–90 dietary intake during this period averaged 14 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*5*). Cesium–137 intakes averaged 32 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	July 1967
January–March 1967	October 1967

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January–June 1966	June 1967
Coast Guard Water Sampling Program	1966	November 1967
Radiostrontium in Tap Water, HASL	March–November 1966	June 1967
Washington Surface Water Sampling	July 1965–June 1966	August 1967

REFERENCES

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Gross Radioactivity in Surface Waters of the United States July 1967

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the

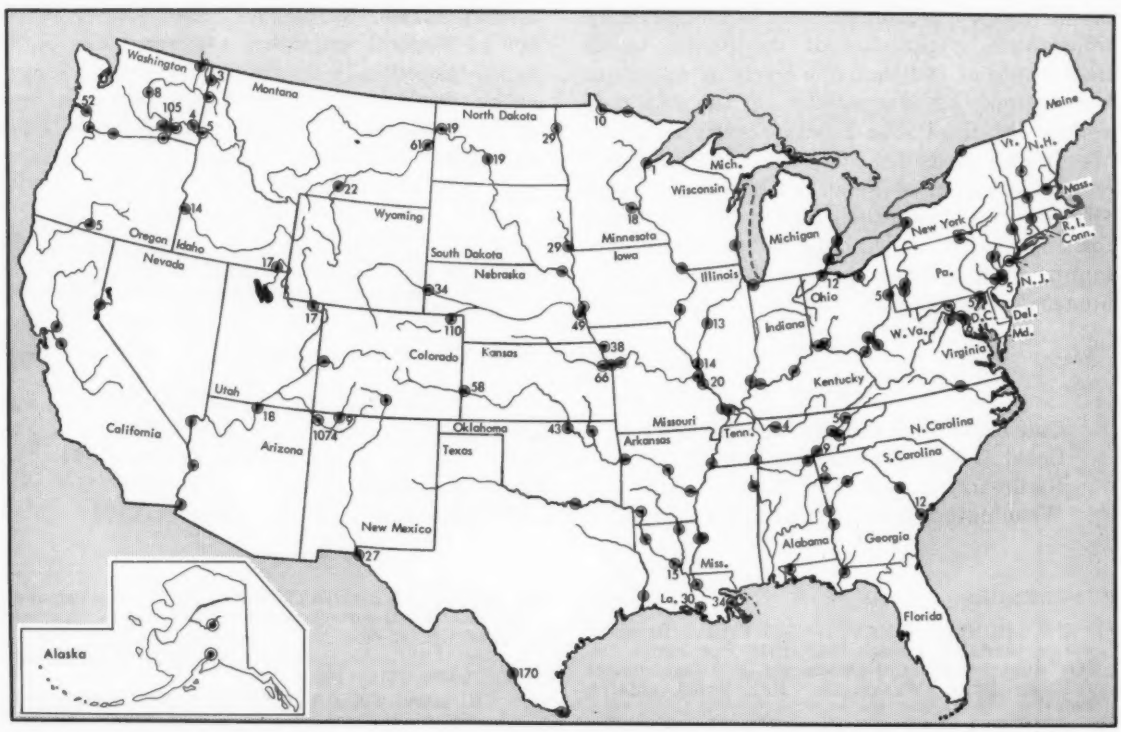

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, July 1967

selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both June and July, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

South Platte River; Julesburg, Colo.
Yellowstone River; Sidney, Mont.

In July, the Coolidge, Kans., station showed a value in excess of 15 pCi/liter on alpha radioactivity in dissolved solids.

The following stations decreased to less than 15 pCi/liter on alpha radioactivity on either suspended or dissolved solids:

Arkansas River; Ponca City, Okla.
Kansas River; DeSoto, Kans.
Missouri River; St. Joseph, Mo.
Platte River; Plattsmouth, Nebr.

Table 1. Radioactivity in raw surface waters, July 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							E. St. Louis, Ill.	1	1	2	10	10	20
Cedar Hill, N. Mex.	<1	1	1	2	7	9	New Orleans, La.	7	0	7	25	9	34
Arkansas River:							Missouri River:						
Coolidge, Kans.	9	21	30	25	33	58	Williston, N. Dak.	4	2	6	11	8	19
Ponca City, Okla.	3	6	9	15	28	43	Bismarck, N. Dak.	1	3	4	4	15	19
Atchafalaya River:							St. Joseph, Mo.	4	4	8	18	20	38
Morgan City, La.	8	1	9	23	7	30	North Platte River:						
Bear River:							Henry, Nebr.	4	14	18	10	24	34
Preston, Idaho	0	2	2	2	15	17	Ohio River:						
Big Horn River:							Toronto, Ohio	0	0	0	0	5	5
Hardin, Mont.	1	3	4	6	16	22	Cairo, Ill.	1	0	1	3	4	7
Big Sioux River:							Pend Oreille River:						
Sioux Falls, S. Dak.	2	2	4	6	23	29	Albeni Falls Dam, Idaho	0	1	1	1	2	3
Clearwater River:							Platte River:						
Lewiston, Idaho	<1	0	<1	3	2	5	Plattsmouth, Nebr.	7	6	13	21	28	49
Clinch River:							Potomac River:						
Clinton, Tenn.	0	0	0	1	4	5	Washington, D. C.	0	0	0	1	5	6
Colorado River:							Rainy River:						
Page, Ariz.	0	5	5	0	18	18	Baudette, Minn.	0	0	0	1	8	9
Columbia River:							Red River, North:						
Wenatchee, Wash.	1	0	1	4	4	8	Grand Forks, N. Dak.	1	3	4	4	25	29
Pasco, Wash.[a]	0	<1	<1	24	81	105	Red River, South:						
Clatskanie, Ore.	0	<1	<1	15	37	52	Alexandria, La.	0	2	2	4	11	15
Connecticut River:							Rio Grande:						
Enfield Dam, Conn.	0	0	0	2	3	5	El Paso, Tex.	1	3	4	9	18	27
Coosa River:							Laredo, Tex.	55	2	57	156	14	170
Rome, Ga.	1	0	1	3	3	6	San Juan River:						
Cumberland River:							Shiprock, N. Mex.	276	6	282	1,048	26	1,074
Cheatham Lock, Tenn.	0	0	0	1	3	4	Savannah River:						
Delaware River:							Port Wentworth, Ga.[a]	1	<1	1	3	9	12
Philadelphia, Pa.	0	0	0	1	4	5	Snake River:						
Great Lakes:							Payette, Idaho	1	2	3	2	12	14
Duluth, Minn.	0	0	0	0	1	1	Wawawai, Wash.	0	1	1	1	3	4
Green River:							South Platte River:						
Dutch John, Utah	0	3	3	1	16	17	Julesburg, Colo.	37	24	61	68	42	110
Illinois River:							Susquehanna River:						
Peoria, Ill.	0	2	2	3	10	13	Conowingo, Md.	0	0	0	1	4	5
Grafton, Ill.	0	3	3	3	11	14	Tennessee River:						
Kansas River:							Chattanooga, Tenn.	1	1	2	2	7	9
DeSoto, Kans.	13	2	15	49	17	66	Yellowstone River:						
Klamath River:							Sidney, Mont.	18	4	22	47	14	61
Keno, Ore.	0	0	0	1	4	5	Maximum	276	24	282	1,048	81	1,074
Maumee River:													
Toledo, Ohio	0	2	2	1	11	12	Minimum	0	0	0	0	1	1
Mississippi River:													
St. Paul, Minn.	0	3	3	2	16	18							

[a] Gross beta radioactivity at these stations may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Laredo, Tex., on the Rio Grande and Shiprock, N. Mex., on the San Juan River reported alpha and beta radioactivity on suspended solids in excess of 15 pCi/liter and 150 pCi/liter for July 1967.

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Radioactivity in Minnesota Municipal Water Supplies[1] January–June 1967

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was intiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250–ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January to June. 1967. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter were coinsidered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 6 to 25 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

[1] Data and information from "Survey of Environmental Radioactivity, January–June 1967," Publication No. COO–651–48. State of Minnesota Department of Health, University Campus, Minneapolis, Minn. 55440.

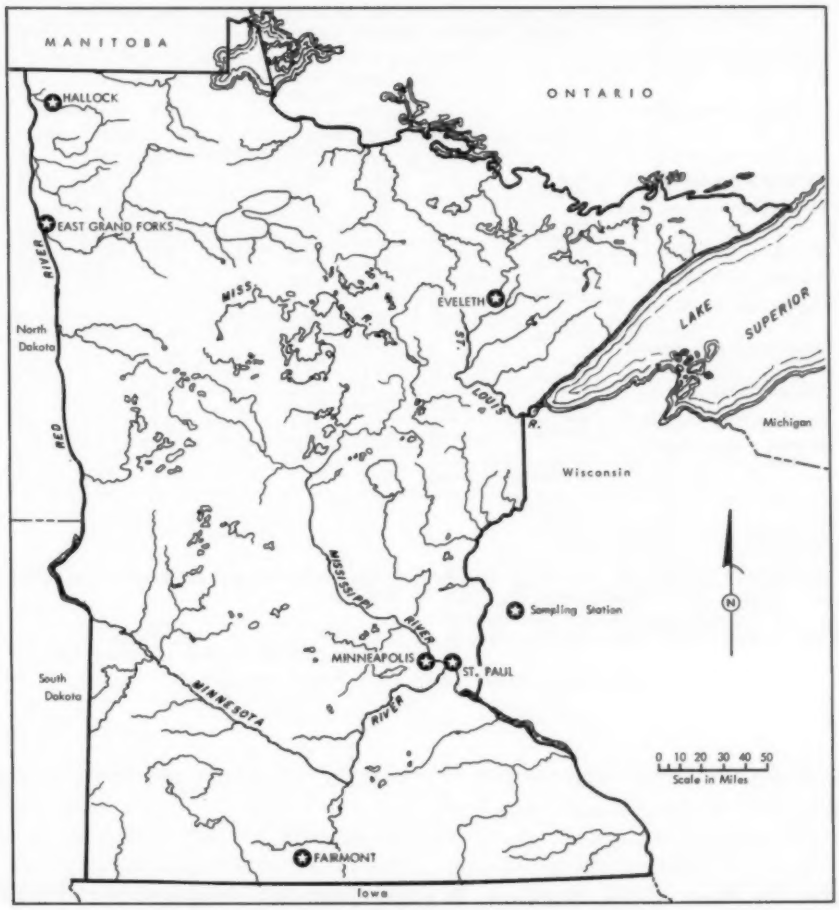

Figure 1. Minnesota surface water sampling locations

Table 1. Total beta-particle concentrations in Minnesota raw and treated water supplies, January–June 1967

Town and water source	Type of water	Average concentrations (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	18	22	16	21	19	22
	Treated	19	17	20	20	19	32
East Grand Forks, Red Lake River	Raw	20	18	19	20	25	18
	Treated	8	9	9	12	13	10
Eveleth, St. Mary's Lake	Raw	10	14	18	12	11	15
	Treated	12	10	14	12	10	12
Fairmont, Budd Lake	Raw	14	14	14	11	11	10
	Treated	6	7	9	6	8	8
Hallock, Two Rivers South Fork	Raw	23	15	20	19	22	23
	Treated	9	6	11	8	9	10
International Falls, Rainy River	Raw	7	6	10	10	13	10
	Treated	6	4	8	9	7	6
Minneapolis tap water	Raw						
	Treated	4	5	5	6	4	6
St. Cloud, Mississippi River	Raw	12	9	9	12	10	9
	Treated	5	5	6	7	9	10
St. Paul, Vadnais Chain of Lakes	Raw	8	10	12	11	11	12
	Treated	4	5	4	4	6	6

Table 2. Total alpha-particle concentrations in Minnesota raw and treated water supplies, January–June 1967

Town and water source	Type of Water	Average concentrations (pCi/liter) Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<3	<1	1	3	3	2
	Treated	<3	1	<1	<1	<1	<1
East Grand Forks, Red Lake River	Raw	1	<1	<1	4	4	1
	Treated	1	<1	<1	1	2	<1
Eveleth, St. Mary's Lake	Raw	<1	<1	<1	<1	<1	<1
	Treated	<1	<1	1	<1	1	<1
Fairmont, Budd Lake	Raw	4	5	4	3	4	4
	Treated	<1	<1	<1	<1	2	1
Hallock, Two Rivers South Fork	Raw	2	1	1	1	2	1
	Treated	<1	1	<1	<1	<1	<1
International Falls, Rainy River	Raw	<1	<1	1	<1	1	<1
	Treated	<1	1	<1	1	2	<1
Minneapolis tap water	Raw						
	Treated	<1	<1	<1	<1	<1	<1
St. Cloud, Mississippi River	Raw	<2	1	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1	<1	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1

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(1) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	October 1967

Radioactivity in New York Surface Water, January–September 1967[1]

Division of General Engineering and Radiological Health
State of New York Department of Health

In 1955 the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 27 locations for gross beta-particle analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger samples are collected at selected locations for strontium–90 analysis.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500 ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solu-

[1] Due to a move of the laboratory, analyses were temporarily curtailed, therefore only January through May data are included in this report.

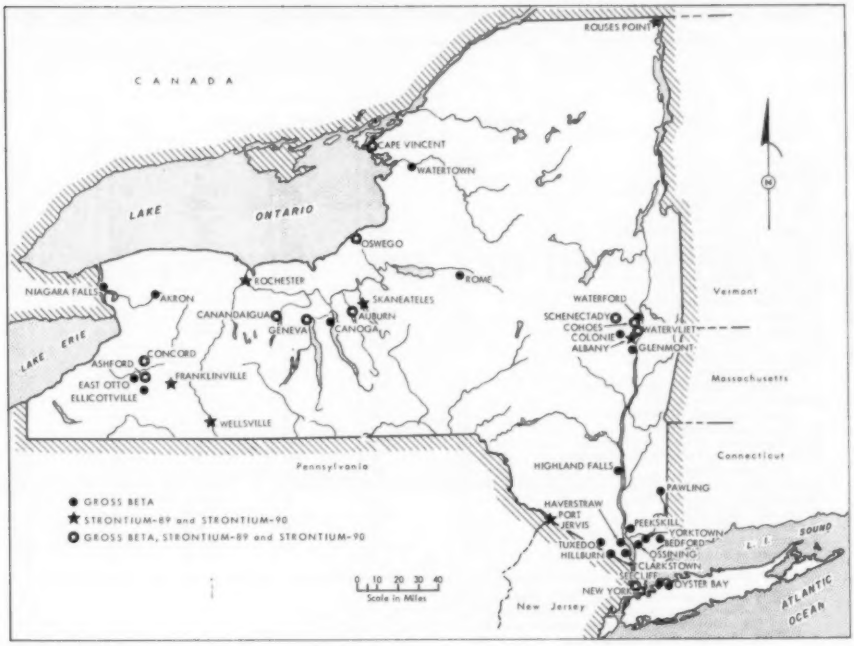

Figure 1. New York water sampling locations

tion. Calcium and yttrium remain in solution as EDTA complexes (*1,2*).

Strontium–90 is determined by yttrium–90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas flow, proportional beta-particle counter. Strontium–89 is estimated by taking the difference between the total strontium and the strontium–90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Discussion and results

The observed gross beta-particle concentrations in New York surface water for January–May 1967 are given in table 1. It should be noted that the Cohoes gross beta-particle results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water sample.

The average concentrations of strontium–89 and strontium–90 in New York water for April through September 1967 for the Concord station are given in table 2.

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Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–December 1966	September 1967

Table 1. Gross beta radioactivity in New York raw surface water, January–May 1967

Location	Sampling [a]	Gross beta radioactivity (pCi/liter)				
		Jan	Feb	Mar	Apr	May
Akron	BW	8	6	NS	NS	NS
Albany	BW	NS	2	4	3	NS
Ashford (Buttermilk Creek)	W	NS	NS	175	312	72
Brant (Cattaraugus Creek)	W	NS	NS	52	17	NS
Cohoes (Mohawk River)	D	4	4	4	4	NS
Collins (Cattaraugus Creek)	M	NS	7	60	16	NS
Colonie (Patroon Creek)	SA	NS	NS	NS	NS	8
Concord (Cattaraugus Creek)	D	101	157	60	41	129
Geneva (Seneca Lake)	SA	NS	4	4	4	NS
Glenmont (Hudson River)	D	5	4	6	10	NS
Highland Falls (Bog Meadow Brook)	M	NS	3	NS	NS	NS
Lansing	SA	NS	NS	NS	NS	8
New York City	SA	NS	5	3	NS	NS
Niagara Falls (East Branch Niagara River)	Q	NS	6	NS	6	NS
(West Branch-Niagara River)	Q	NS	4	NS	NS	NS
Ossining (Hudson River)	D	35	9	23	1	NS
(Indian Brook Reservoir)	M	6	4	NS	5	NS
Oswego (Lake Ontario)	M	4	4	NS	4	4
Pawling (Pond at United Nuclear)	M	NS	NS	5	4	NS
Peekskill (Camp Field Water Supply)	M	6	NS	5	4	NS
(Hudson River)	D	25	18	20	4	NS
Rome (Fish Creek)	BW	4	NS	NS	NS	NS
Schenectady (Mohawk River)	C	5	4	3	4	NS
Tuxedo (Indian Hill)	M	NS	3	5	3	NS
Watertown (Black River)	BW	13	4	4	5	4
Watervliet (French Mills Reservoir)	BW	4	4	NS	NS	NS
Yorktown (Croton Reservoir)	M	2	7	NS	4	NS

[a] BW-Biweekly composite of daily grab samples.
D-Weekly composite of daily grab samples.
C-Continuous bleed-off-analyzed weekly.
M-Monthly grab sample.
Q-Quarterly grab sample.
SA-Semiannual grab sample.
NS, no sample.

Table 2. Strontium–89 and strontium–90 in New York surface waters, April–September 1967

Location	Month 1967	Radionuclide concentration (pCi/liter)	
		Strontium-89	Strontium-90
Concord [a] (Springville Power Dam on Cattaraugus Creek)	April	<3	21
	May	9	13
	July	NA	38
	August	NA	53
	September	NA	15

[a] These samples were collected from a sampling station located downstream from the Nuclear Fuel Services Spent Fuel Processing Plant located in Cattaraugus County.
NA, no analysis.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January–March 1967	September 1967

1. Radiation Surveillance Network September 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity by the station operators. These estimates are made after the decay of radon and partial decay of thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*. The described procedures have been modified in that laboratory gross beta radioactivity analysis and gamma-ray spectroscopy are no longer performed on air samples having a field estimate below 10 pCi/m³. Reporting field estimates only may cause an apparent increase in the published airborne radioactivity levels proportional to the amount of thoron daughter radioactivity present in the sample. In extreme cases, this increase may be as much as 2 orders of magnitude, but usually will be of the order of a factor of 2 or less. The maximum field estimates reported by RSN stations attributable to thoron daughter radioactivity have ranged from 15 to 20 pCi/m³ at 5 hours after collection.

Figure 1. Radiation Surveillance Network sampling stations

Table 1 presents the monthly average gross beta radioactivity in surface air particulates as measured by the field estimate and deposition by precipitation during September 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Table 1. Gross beta radioactivity in surface air and precipitation, September 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	5	8.50	0.28	2.54	Nov 67	162	<33
Alaska:	Adak	30	----	.36	0.36	.36	June 67	[c]	----
	Anchorage	20	8	.00	.00	.00	Dec 67	81	<16
	Attu Island	[b]	----	----	----	----	July 67	[c]	----
	Fairbanks	[b]	----	----	----	----	Jan 68	[c]	----
	Juneau	20	18	.49	.00	.12	Apr 67	306	<62
	Kodiak	11	----	1.45	.29	.71	May 67	[c]	----
	Nome	5	----	.97	.00	.67	Sept 67	[c]	----
	Pt. Barrow	30	----	.62	.59	.60	Aug 67	[c]	----
	St. Paul Island	[b]	----	----	----	----	Oct 67	[c]	----
Ariz:	Phoenix	[b]	----	----	----	----	Apr 67	[c]	----
Ark:	Little Rock	16	8	2.00	.57	1.20	Dec 67	145	<29
Calif:	Berkeley	20	----	1.24	.00	.23	May 67	[c]	----
	Los Angeles	19	3	.97	.20	.48	Sept 67	8	< 2
C. Z:	Ancon	16	----	2.00	.67	1.32	May 67	[c]	----
Colo:	Denver	16	----	6.01	.14	3.12	May 67	[c]	----
Conn:	Hartford	20	5	1.01	.23	.44	Jan 68	36	< 7
Del:	Dover	19	----	2.23	.21	.70	Nov 67	[c]	----
D. C:	Washington	30	2	3.02	.25	1.03	Aug 67	10	< 2
Fla:	Jacksonville	20	3	1.03	.25	.37	Dec 67	36	< 7
	Miami	17	8	.23	.07	.15	Jan 68	136	<27
Ga:	Atlanta	19	3	3.27	.39	1.08	Oct 67	47	<10
Guam:	Agana	29	----	2.49	.00	.47	Nov 67	[c]	----
Hawaii:	Honolulu	30	----	.80	.31	.41	July 67	[c]	----
Idaho:	Boise	29	1	6.36	.82	2.23	July 67	9	< 2
Ill:	Springfield	20	4	6.50	.00	1.74	Aug 67	76	<15
Ind:	Indianapolis	19	4	7.48	.70	1.98	Oct 67	16	< 3
Iowa:	Iowa City	21	4	10.33	.53	2.40	May 67	69	<14
Kans:	Topeka	16	7	12.12	.64	3.61	Dec 67	100	<20
Ky:	Frankfort	16	5	6.34	.71	2.45	Aug 67	31	< 6
La:	New Orleans	20	----	1.46	.04	.23	Aug 67	[c]	----
Maine:	Augusta	21	5	1.82	.08	.58	Sept 67	91	<18
Md:	Baltimore	19	1	3.47	.19	1.19	Jan 68	5	< 1
	Rockville	4	----	.78	.05	.34	July 67	[c]	----
Mass:	Lawrence	17	7	3.88	.59	1.41	Nov 67	72	<15
	Winchester	19	6	4.91	.00	1.03	June 67	55	<11
Mich:	Lansing	19	6	6.56	.51	1.98	July 67	42	< 8
Minn:	Minneapolis	20	3	.42	.18	.24	Nov 67	22	< 4
Miss:	Jackson	18	3	2.78	.14	.81	Sept 68	50	<13
Mo:	Jefferson City	20	7	3.19	.19	.94	Oct 67	75	<15
Mont:	Helena	20	3	3.45	.25	1.21	June 67	7	< 1
Nebr:	Lincoln	18	9	2.80	.22	1.11	Oct 67	74	<15
Nev:	Las Vegas	26	----	1.74	.22	.58	Jan 68	[c]	----
N. H:	Concord	19	----	3.30	.46	1.12	Aug 67	[c]	----
N. J:	Trenton	20	1	1.06	.21	.47	Sept 67	2	< 1
N. Mex:	Santa Fe	20	6	1.46	.21	.57	June 67	30	< 6
N. Y:	Albany	21	5	1.87	.17	.73	Oct 67	48	<10
	Buffalo	12	----	1.19	.07	.42	May 67	[c]	----
	New York City	20	----	.37	.13	.21	June 67	[c]	----
N. C:	Gastonia	16	----	15.02	1.10	5.10	May 67	[c]	----
N. Dak:	Bismarck	19	6	3.54	.77	1.84	Aug 67	55	<11
Ohio:	Cincinnati	20	----	6.52	.58	2.87	Nov 67	[c]	----
	Columbus	19	3	4.56	.00	1.70	Sept 67	57	<11
	Painesville	19	5	3.15	.29	1.20	Jan 68	59	<12
Okla:	Oklahoma City	18	1	1.01	.00	.19	July 67	56	<11
	Ponca City	22	8	1.37	.08	.52	Jan 68	173	<35
Ore:	Portland	19	2	2.33	.24	.81	Oct 67	9	< 2
Pa:	Harrisburg	19	----	3.27	.53	1.36	Oct 67	[c]	----
P. R:	San Juan	11	2	.44	.00	.03	Sept 67	50	<10
R. I:	Providence	20	4	.98	.00	.32	July 67	60	<12
S. C:	Columbia	9	3	1.13	.00	.38	June 67	95	<19
S. Dak:	Pierre	17	----	7.48	.97	3.10	Apr 67	[c]	----
Tenn:	Nashville	19	4	4.58	.11	1.31	July 67	81	<16
Tex:	Austin	19	----	6.98	.01	3.01	Nov 67	[c]	----
	El Paso	30	5	5.70	.76	2.02	Aug 67	24	< 5
Utah:	Salt Lake City	30	5	1.25	.22	.50	Sept 67	20	< 4
Vt:	Barre	19	6	2.42	.00	.92	Dec 67	56	<11
Va:	Richmond	17	4	1.64	.22	.81	Dec 67	15	< 3
Wash:	Seattle	13	----	.55	.00	.05	Dec 67	[c]	----
	Spokane	20	1	2.91	.41	1.21	Nov 67	3	< 1
W. Va:	Charleston	19	6	3.14	.24	1.37	June 67	43	< 9
Wis:	Madison	20	5	2.48	.32	.96	Dec 67	62	<12
Wyo:	Cheyenne	20	3	5.97	.95	2.45	Jan 68	22	< 5
Network summary		1,345	223	15.02	0.00	1.15	----	59	<12

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
[b] Indicates no report of field estimate received.
[c] Indicates no precipitation sample collected.

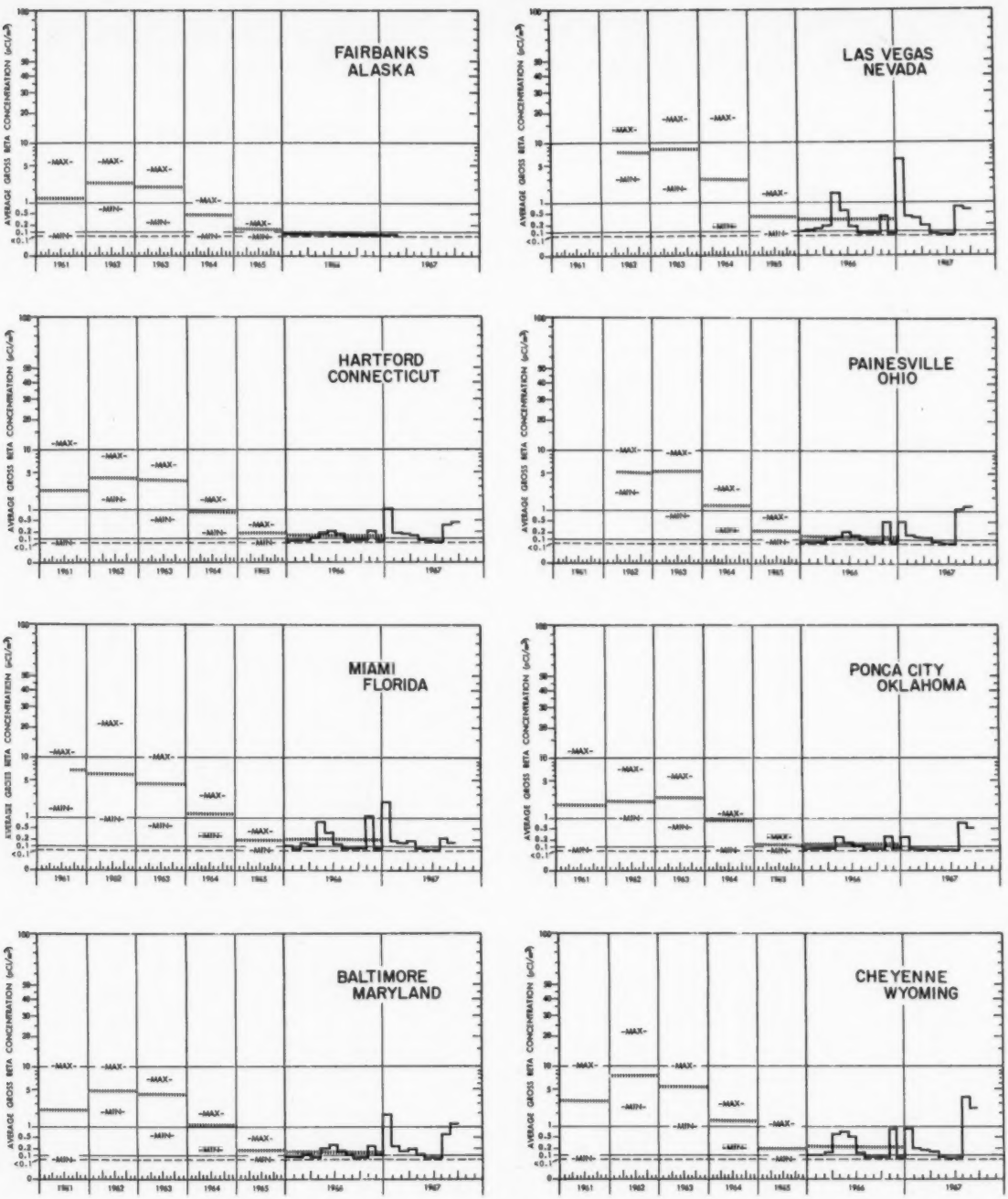

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961–September 1967

2. Canadian Air and Precipitation Monitoring Program, September 1967

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the November 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for September 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.0	0.0	0.0	(a)	0.3
Coral Harbour	13	.0	.0	.0	17	1.1
Edmonton	30	.0	.0	.0	98	0.3
Ft. Churchill	30	.0	.0	.0	3	0.1
Ft. William	30	6.3	.0	.2	26	0.8
Fredericton	30	1.6	.0	.1	2	0.4
Goose Bay	30	.0	.0	.0	7	0.5
Halifax	30	.0	.0	.0	4	0.5
Inuvik	30	.0	.0	.0	13	0.3
Montreal	30	.0	.0	.0	10	0.5
Moosonee	30	.0	.0	.0	18	0.6
Ottawa	30	4.5	.0	.2	8	1.0
Quebec	30	.0	.0	.0	44	2.9
Regina	30	.0	.0	.0	12	1.0
Resolute	30	.0	.0	.0	NS	NS
St. John's, Nfld.	30	.0	.0	.0	14	1.5
Saskatoon	30	.0	.0	.0	20	0.7
Saulte Ste Marie	30	.0	.0	.0	33	1.0
Toronto	30	.0	.0	.0	4	0.2
Vancouver	30	.0	.0	.0	12	0.7
Whitehorse	30	.0	.0	.0	14	0.2
Windsor	30	2.9	.0	.1	40	2.2
Winnipeg	30	1.3	.0	.1	41	0.9
Yellowknife	30	.0	.0	.0	30	0.3
Network summary	703	6.3	0.0	0.0	21	0.8

[a] Trace precipitation.
NS, no sample.

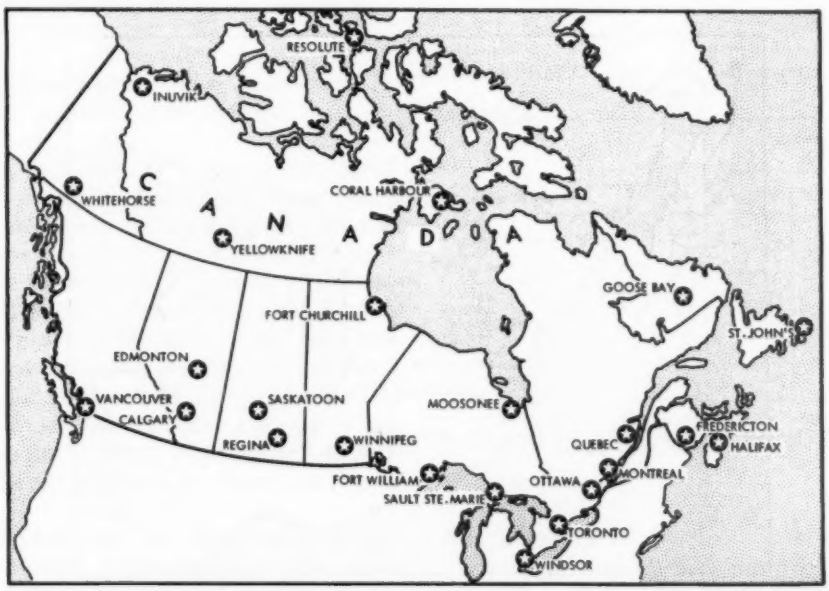

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program September 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (1).

The maximum, minimum, and average beta radioactivity in surface air during September 1967 are presented in table 3.

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	16	0.1	<0.1	<0.1
Chihuahua	NS			
Ciudad Juáres	NS			
Ensenada	11	0.3	<0.1	0.1
Guadalajara	6	0.1	<0.1	<0.1
Guaymas	NS			
La Paz	13	0.1	<0.1	0.1
Matamoros	NS			
Masatlán	11	0.1	<0.1	<0.1
Mérida	10	0.1	<0.1	<0.1
México, D. F.	10	0.1	<0.1	<0.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	11	0.4	<0.1	0.1
Torréon	21	0.1	<0.1	0.1
Veracruz	9	0.1	<0.1	<0.1

NS, indicates no sample collected, station temporarily shutdown.

Figure 5. Pan American Air Sampling Program stations

4. Pan American Air Sampling Program September 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network before July 31, 1967. The air sampling locations are shown in figure 5.

The September 1967 air monitoring results are given in table 4. Airborne gross beta radioactivity levels have decreased since August and are at or near normal at all stations.

Table 4. PAHO gross beta radioactivity in surface air September 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	9	0.29	0.03	0.12
Bolivia: La Paz	19	.35	.05	.11
Chili: Santiago	28	.34	.05	.12
Colombia: Bogota	21	.09	.00	.02
Ecuador: Guayaquil	30	.19	.03	.09
Jamaica: Kingston	8	.04	.00	.01
Peru: Lima	25	.44	.04	.16
Venezuela: Caracas	19	.10	.01	.03
West Indies: Trinidad	18	.09	.00	.05
Pan American summary	177	0.44	0.00	0.08

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Radionuclides in Alaskan Caribou and Reindeer, March-May 1967

National Center for Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou herds and one privately owned reindeer herd. This program was expanded in September 1964, when the sampling of additional privately owned and government owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of the Interior.

Figure 1 shows the locations of the principal caribou and reindeer herds in Alaska. The code indicates the herds that were sampled during the spring of 1967.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Muscle and rumen content samples of five separate animals from each herd are collected during the sampling period. Hock joint bones from five animals are collected only from the Nome herd during the fall collection period. Muscle samples are analyzed individually and rumen content samples from each herd are composited before analysis for cesium–137 by gamma-ray spectroscopy. Muscle and bone samples from the individual herd are composited before analysis for strontium–89 and strontium–90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium–89, strontium–90, and cesium–137 data are presented in table 1 for caribou muscle, reindeer muscle, and rumen contents for the March–May 1967 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. A comparison of the muscle data for spring 1966 and spring 1967 is shown in table 2.

The cesium–137 concentrations in the spring of 1967 are quite similar to those found for the spring of 1966 with the exception of the

Peninsula reindeer herd. The level in 1967 was almost one-third the level in 1966. The reason for this is unknown although the grazing area and diet can vary considerably at different times. A summary of strontium–90 and cesium–137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports.*

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–November 1966	May 1967

NOTE—Correction for Previous Data

During the initial sampling period, analysis of cesium–137 in caribou and reindeer muscle samples from Alaska was performed under non-standard geometry conditions. Since July 1965, a standard procedure has been utilized. Cesium–137 concentrations in samples analyzed with the new procedure were found to be in a range of 1.2 to 1.9 times greater than when the samples were analyzed in a non-standard geometry. Although a correction factor cannot be established for each sample result, this difference should be kept in mind when using analytical results for samples collected and analyzed prior to July 1965, as reported in the December 1964, May 1965, March 1966, and December 1966 issues of *Radiological Health Data and Reports.*

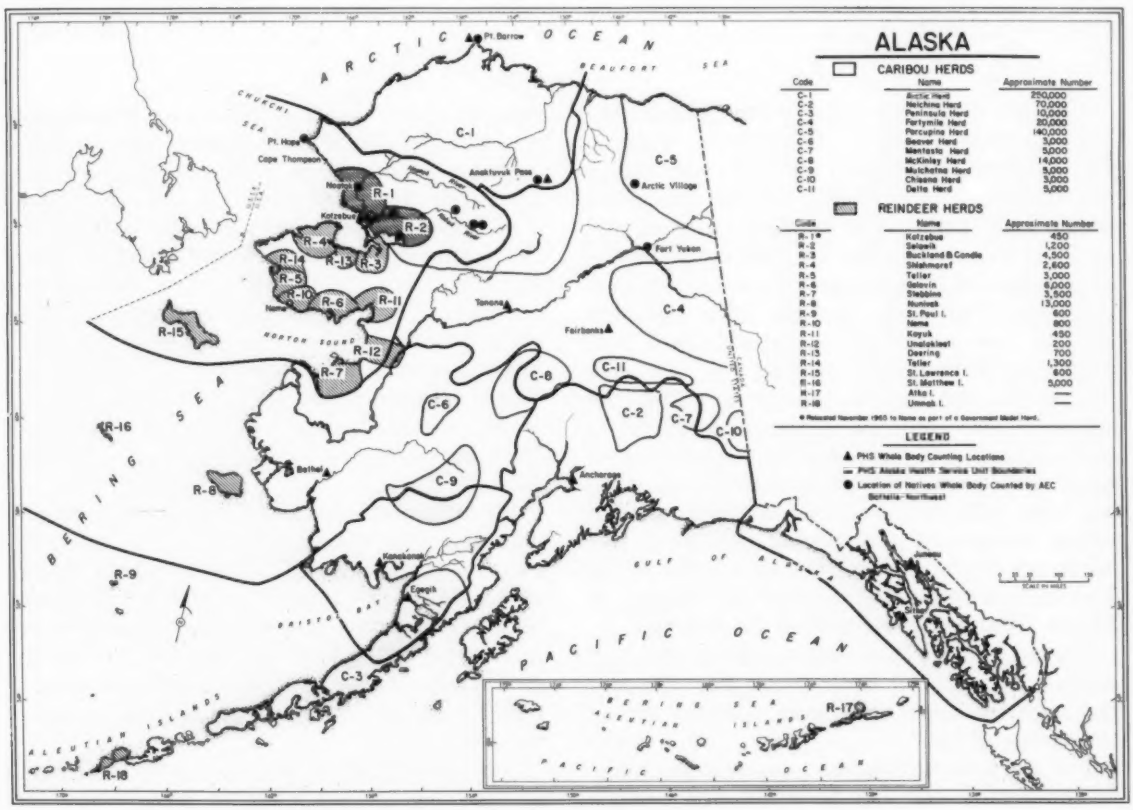

Figure 1. Location of caribou and reindeer herds in Alaska

Table 1. Radionuclide concentration in muscle and rumen of Alaskan caribou and reindeer, March–May 1967

Herd and sampling location [a]	Collection date, 1967	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)
				^{89}Sr [b]	^{90}Sr [b]	^{137}Cs	^{137}Cs
Arctic caribou herd							
Anaktuvuk Pass, C-1	5/4	M	3	----	----	24×10^3	19×10^3
	5/6	F	9	8	28	31×10^3	
		F	2	----	----	30×10^3	
		F	5	----	----	23×10^3	
		F	5	----	----	21×10^3	
Nelchina caribou herd							
Dickey Lake, C-2	3/15	M	4	<5	2	17×10^3	7.1×10^3
	3/16	M	4	----	----	12×10^3	
	3/21	M	3	----	----	16×10^3	
		F	5	----	----	13×10^3	
		F	4	----	----	11×10^3	
Peninsula caribou herd							
King Salmon, C-3	4/15	M	2	<5	2	16×10^3	2.5×10^3
		M	3	----	----	13×10^3	
	4/16	F	3	----	----	18×10^3	
		F	1	----	----	14×10^3	
		F	calf	----	----	18×10^3	
Shishmaref reindeer herd,							
Seward Peninsula, R-4	5/1	F	2	<5	16	13×10^3	6.4×10^3
		F	1	----	----	19×10^3	
		F	1	----	----	16×10^3	
		M	3	----	----	20×10^3	
		M	4	----	----	15×10^3	
Nunivak Island,							
reindeer herd, R-8	4/26	M	3	<5	20	27×10^3	9.5×10^3
		F	3	----	----	30×10^3	
		F	3	----	----	26×10^3	
		F	3	----	----	46×10^3	
		M	3	----	----	33×10^3	
Nome reindeer herd, R-10	4/8	F	7	<5	34	23×10^3	14×10^3
		F	8	----	----	23×10^3	
		M	2	----	----	24×10^3	
		M	3	----	----	20×10^3	
		M	4	----	----	19×10^4	

[a] Sampling locations are shown in figure 1.
[b] Composite of individual samples taken within the herd.

Table 2. Spring cesium–137 concentrations in caribou and reindeer muscle, 1966–1967

Herd	Average cesium-137 concentration (pCi/kg wet weight)	
	Spring 1966	Spring 1967
Arctic caribou	18×10^3	26×10^3
Nelchina caribou	13×10^3	14×10^3
Peninsula caribou	44×10^3	16×10^3
Shismaref reindeer	19×10^3	17×10^3
Nunivak reindeer	33×10^3	32×10^3
Nome reindeer	22×10^3	22×10^3

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Paducah Plant, Portsmouth Area Gaseous Diffusion Plant, and the Rocky Flats Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Paducah Plant
January–June 1967 [2]

Union Carbide Corporation
Paducah, Kentucky

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed, was placed on standby in June of 1964. Parts of the associated uranium metal foundry, usually on standby, were operated during most of this report period. A decontamination and uranium recovery facility operates to prepare equpment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234 and protactinium–234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery systems at the plant. The environmental monitoring program provides for continuously sampling air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 1). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air

[2] Summarized from "Environmental concentrations of radioactive materials near the Paducah Plant—Report for the First Half of 1967."

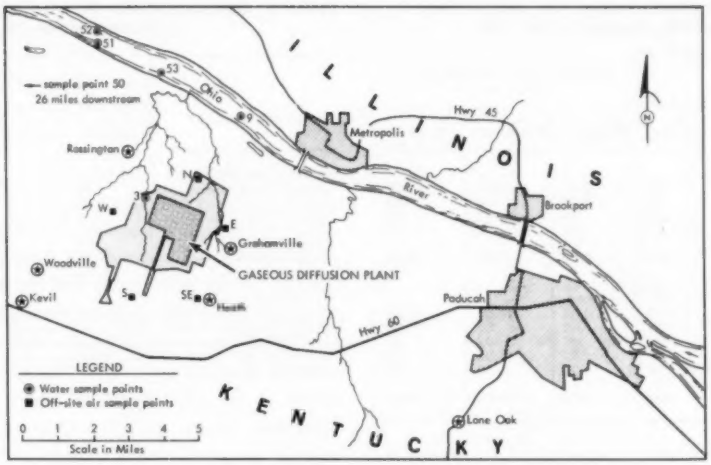

Figure 1. Sampling locations, Paducah Plant

sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employes and for offsite exposure of the general population, are those contained in Appendix 0524 of the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 4.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha-particle count — interpreted as uranium, the most likely source of radioactivity—of the 234 air samples collected during the first half of 1967 were less than 1 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The mean beta-particle count of the same samples was 0.02 percent of the standard.

The average uranium analysis of weekly water samples collected continuously from the Big Bayou Creek during the first half of 1967 was 0.03 percent of the AEC standard for water beyond a controlled area. The results of the uranium analyses for each of the 6 grab samples collected at monthly intervals from the

Table 1. Uranium concentrations in outdoor air samples, Paducah, January–June 1967

Sample location [a]	Number of samples	Uranium alpha radioactivity [b] (pCi/m³)		
		Maximum	Minimum [c]	Mean [d]
At plant perimeter fence:				
North	26	0.06	<0.02	<0.02
East	26	.20	< .02	.03
South	26	.03	< .02	< .02
West	26	.02	< .02	< .02
Total, January–June	104	0.20	<0.02	<0.02
About 1 mile outside plant perimeter fence:				
North	26	0.02	<0.02	<0.02
East	26	.02	< .02	< .02
South	26	.06	< .02	< .02
West	26	.02	< .02	< .02
Southeast	26	.02	< .02	< .02
Total, January–June	130	0.06	<0.02	<0.02

[a] See map in figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m³.

Table 2. Beta radioactivity in outdoor air samples, Paducah, January–June 1967

Sample location [a]	Number of samples	Beta radioactivity (pCi/m³)		
		Maximum	Minimum [b]	Mean [c]
At plant perimeter fence:				
North	26	1.3	<0.1	0.18
East	26	2.0	< .1	.32
South	26	0.48	< .1	.14
West	26	1.7	< .1	.20
Total, January–June	104	2.0	< .1	0.22
About 1 mile outside plant perimeter fence:				
North	26	1.1	< .1	.19
East	26	0.9	< .1	.18
South	26	2.6	< .1	.25
West	26	0.44	< .1	.10
Southeast	26	4.3	< .1	.29
Total, January–June	130	4.3	<0.1	0.20

[a] See map in figure 1.
[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m³.
[c] The AEC standard, applicable to this table is 1×10^3 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 3. Concentrations of uranium in water, Paducah January–June 1967

Sample location [a]	Number of samples	Uranium concentrations [b] (pCi/liter)		
		Maximum	Minimum [c]	Mean [d]
January–June 1967:				
Big Bayou Creek 3	26	32	<1	5
Ohio River 9	6	2	<1	1
Composite of 50, 51, 52, and 53	6	1	<1	<1

[a] See map in figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The AEC standard for natural uranium in water beyond a controlled area is 2×10^4 pCi/liter.

Table 4. Concentration of beta-particle emitters in water, Paducah, January–June 1967

Sample location [a]	Number of samples	Beta-particle emitters (pCi/liter)		
		Maximum	Minimum [b]	Mean [c]
January–June 1967:				
Big Bayou Creek 3	26	500	<100	100
Ohio River 9	6	<100	<100	<100
Composite of 50, 51, 52, and 53	6	<100	<100	<100

[a] See map in figure 1.
[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.
[c] The AEC standard for the immediate daughter products of uranium in water released to the environs is 2×10^4 pCi/liter.

Ohio River below the plant were less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big Bayou Creek averaged 0.5 percent of the AEC standard for the decay products of uranium–238 during the first half of 1967. The beta radioactivity of the Ohio River was at or below the minimum detectable level during the first half of 1967, and the results of all samples during the year averaged less than 0.5 percent of the standard for uranium–238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hr at all sampling stations for January–June 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	January 1967
July–December and calendar year 1966	July 1967

2. Portsmouth Area Gaseous Diffusion Plant [3] January–June 1967

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha-particle emitter and thorium–234 is a beta-particle and gamma-ray emitter, environmental monitoring is conducted for evidence of alpha-particle, beta-particle and gamma-ray emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 2. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1967, the waterborne alpha radioactivity, airborne alpha, beta-gamma radioactivity, and the background dose rate remained substantially unchanged compared with the 1966 results. The waterborne beta-gamma radioactivity, however, increased for the first half of 1967. This increase was caused by one sample obtained from a plant effluent stream inside the plant boundaries (the results showed only 6.0 percent of the AEC concentration standards). Samples taken downstream of all plant effluent showed a dilution factor of 17 to 1.

Average background exposure rates remained unchanged from the 1966 values. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

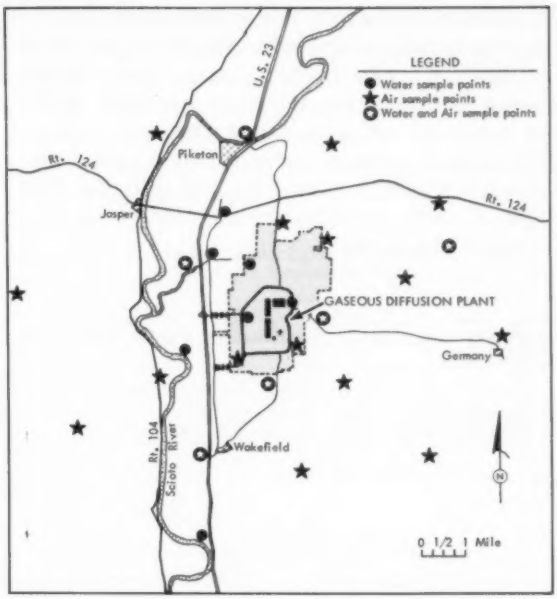

Figure 2. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Table 5. Environmental radioactivity, Portsmouth Plant January–June 1967

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard [a]
Air					
Alpha radioactivity (pCi/m³)	126	0.3	< 0.0	< 0.0	< 5.0
Beta-gamma radioactivity (pCi/m³)	126	1.7	< .1	< .1	.02
Water					
Alpha radioactivity (pCi/liter)	71	230	< .5	17.5	.09
Beta-gamma radioactivity (pCi/liter)	71	1,170	<14.0	39.7	.20
Background exposure [b] (mrad/hr)	126	.030	.101	.014	17.5

[a] Trace precipitation.
[a] The applicable AEC standards are as follows:

Air (alpha radioactivity)	2 pCi/m³
Air (beta-gamma radioactivity)	1×10^3 pCi/m³
Water (alpha radioactivity)	2×10^4 pCi/liter
Water (beta-gamma radioactivity)	2×10^4 pCi/liter
External beta-gamma radioactivity	0.5 rem/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

[3] Data summarized from B. Kalman and S. H. Hulett: "Environmental Radiation Levels and Concentrations—First Half 1967," GAT–552 (July 20, 1967).

Average alpha and beta gamma radioactivity concentrations in air and water are summarized in table 5. The external gamma-ray levels, measured at the air sampling locations shown in figure 2, are also summarized in table 5. The overall average concentrations and background exposure rates for 1966 and the first half of 1967 are presented in table 6 as percents of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	January 1967
July–December 1966	September 1967

Table 6. Comparison of average concentrations Portsmouth Plant, 1966 and first half 1967

Type of monitoring	Percent of AEC standard [a]			
	1967	1966		
	First half	First half	Second half	Calendar year
Air				
Alpha radioactivity	< 5.0	7.3	< 5.0	1.4
Beta-gamma radioactivity	0.02	0.03	0.01	0.02
Water				
Alpha radioactivity	.09	.07	.09	.09
Beta-gamma radioactivity	.20	.07	.05	.05
Background exposure extrapolated to 3 feet above ground level	17.5	17.7	17.1	17.4

[a] See footnote [a] of table 5.

3. Rocky Flats Plant [4] January–June 1967

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha-radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 7 are believed to result from naturally occurring materials. All values are less than the AEC standard of 0.04 pCi/m^3 for mixtures of unidentified radionuclides.

Table 7. Long-lived gross alpha radioactivity in airborne particulates, RFP environs, January–June 1967

Period	Average concentration (pCi/m^3)
January	1.0×10^{-3}
February	0.4×10^{-3}
March	0.5×10^{-3}
April	0.7×10^{-3}
May	0.6×10^{-3}
June	0.7×10^{-3}

[4] Summarized from "Environmental Survey, January–June 1967," the Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Water

Regular water samples were obtained monthly except during the winter months from four reservoirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 8. The analytical results for water samples obtained during June from outlying streams and lakes will be presented in the next report. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 8. Alpha radioactivity in water, RFP environs January–June 1967

Reservoir	Number of samples	Average alpha radioactivity (pCi/liter)
Great Western	5	2.3
Standley	5	1.0
Baseline	6	1.3
Ralston	6	1.8

Vegetation

During September 1966, 104 samples of vegetation were collected in the vicinity of Rocky Flats Plant at locations up to 18 miles distant from the plant. Gross alpha radioactivity counts were made on the samples. The results are reported in table 9.

Table 9. Alpha radioactivity in vegetation, RFP environs, September 1966

Collection period	Distance from plant	Number of samples	Average concentration (pCi/kg dry weight)
September 1966	Less than 3 miles	60	91
	3 to 18 miles	44	78

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	December 1966
July–December 1966	May 1967

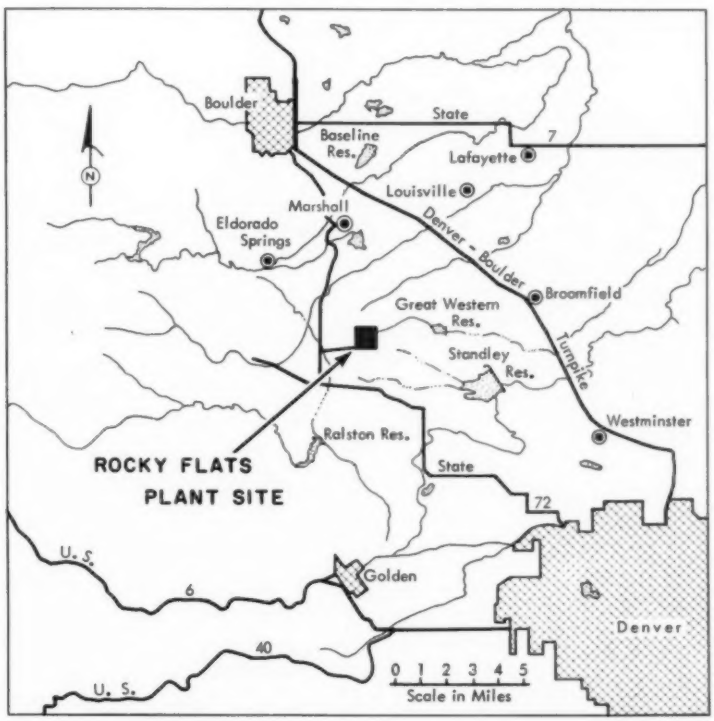

Figure 3. Rocky Flats Plant and environs near Denver, Colorado

Reported Nuclear Detonations, December 1967

The U.S. Atomic Energy Commission detonated a nuclear explosive deep underground in northwestern New Mexico on December 10, 1967, in a natural gas reservoir stimulation experiment called "Project Gasbuggy." The explosive was fired 4,240 feet beneath the surface at 2:30 p.m. Eastern Standard Time some 55 air miles east of Farmington. There was no measurable release of radioactivity and no report of damage from ground shock. Radiation and health safety experts monitored the area as a precaution. Prior to the detonation, pipelines taking gas from wells in the 5-mile radius around the site were visibly cut apart from the El Paso Natural Gas Company System. The nuclear explosive had a designed yield of 26 kilotons. The explosion was designed to create a cavity 160 feet in diameter, which would then collapse, forming a zone or chimney of shattered and broken rock 160 feet in diameter and about 350 feet high. This is more than 3,500 feet underground through the tight gas bearing formation.

On December 15, 1967, the U.S. AEC announced that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at its Nevada Test Site.

On December 24, 1967, the Atomic Energy Commission announced that the U.S. had detected the Seventh Chinese Communist atmospheric nuclear test in the Lop Nor area on December 24, Chinese time. The detonation was in the low yield range.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

GROSS RADIOACTIVITY OF THE SOLIDS IN SELECTED SURFACE WATERS OF THE UNITED STATES, 1961–1965. *Elmo C. Julian. Radiological Health Data and Reports, Vol. 9, January 1968, pp. 1–16.*

Gross radioactivity has been expressed in pCi/liter of water but to to understand the movement of radiological contamination in the absence of flow data, the consideration of radioactivity in the suspended and dissolved solids in pCi/g is quite useful. The gross radioactivity of the solids in some surface waters of the United States is presented and interpreted in this report with the data from stations of the Water Pollution Surveillance System for the years 1961 through 1965.

Radioactivity levels in surface waters as modified by seasonal runoff patterns are reported. The radioactivity of solids collected below two production reactor facilities was measured and a trend is indicated.

KEY WORDS: Alpha radioactivity, beta radioactivity, fallout, Federal Water Pollution Control Administration, gross radioactivity, natural radioactivity, solids quality, surface waters, water quality.

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